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CHANGES IN URINE AND SERUM ELECTROLYTES AND PLASMA VOLUMES AFTER MAJOR INTRATHORACIC OPERATIONS

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WITHIN recent years, surgeons have become more aware of the importance of changes in fluid and electrolyte distribution and excretion following major operations. However, we have been unable to find any report of the serum concentration and renal excretion of the chief extracellular electrolytes in a series of patients subjected to major intrathoracic operations. The following study was undertaken in the hope that further information regarding the physiologic disturbances following major intrathoracic operations would result in improved pre- and postoperative care.

MATERIAL AND METHOD

Nineteen patients subjected to major intrathoracic operations were studied on the surgical service of the Jefferson Hospital. Thirteen patients had carcinoma of the lung. In seven of these, pneumonectomy was performed. Six lesions were found to be nonresectable after extensive dissection. Three patients had carcinoma of the esophagus. In two patients, an esophagectomy and esophagogastrostomy was performed. The lesion in the third patient was not resectable. In one patient a total esophagectomy and pharyngogastrostomy was performed for lye stricture of the esophagus. One patient had severe respiratory obstruction from a mediastinal tumor which was successfully removed. In the remaining case, a tuberculoma was excised. All of these operations were considered sufficiently extensive to warrant these studies.

The usual diagnostic studies were performed. Routine hospital laboratory tests gave no evidence of gross impairment of renal or hepatic function. Before operation, determinations of plasma volume and hematocrit were performed. Transfusions were given to bring the blood volume up to a level near that given as normal for the patient's surface area by the nomogram of Boothby and Sandi-

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ford.[17] The surface area was determined using the patient's height and weight prior to the onset of his illness. Blood loss was measured and replaced at the time of operation. The patients studied later in the series were given plasma or ossein gelatin* in the immediate postoperative period. Ossein gelatin prepared in 6 per cent solution is hypertonic. Five hundred milliliters have the osmotic equivalence of 750 ml. of isotonic plasma. About 50 per cent of the gelatin remains in the circulation at the end of twenty-four hours. It is largely excreted by the kidneys.[13, 24, 34] All patients were given one or two liters of 5 per cent glucose in water on the day of operation. The fifteen patients with lesions elsewhere than in the esophagus required supplementary intravenous fluids during the first or second postoperative days. Five of these patients received 76 to 153 meq. of sodium and three received 27 or 53 meq. of potassium. The four patients with esophageal disease required parenteral fluid for longer periods. Approximately 100 meq. of sodium and 26 meq. of potassium were given daily during the period of parenteral feeding. One patient considered separately below received larger quantities of sodium.

The special studies were made in the following manner in our laboratory. Blood specimens taken from an artery, or from a vein without stasis, were centrifuged within thirty minutes and the serum promptly removed. Urine specimens were collected for twenty-four hour periods. Sodium and potassium determinations were made in duplicate with the Barclay internal standard flame photometer[3, 4] which has a reproducible accuracy in our hands of 1½ per cent. The chloride determinations were done according to the method of Schales and Schales.[39] Total eosinophil counts were made promptly after the withdrawal of blood samples.[15, 21, 38, 42] Plasma volumes were measured using the T1824 dye dilution technique of Gibson and Evans[16] modified for the photoelectric colorimeter by Gibson and Evelyn.[18] In most instances, specimens were obtained from an indwelling arterial needle as described by Noble and Gregersen.[33] This facilitated prompt withdrawal of timed specimens, obviated the danger of stasis, decreased hemolysis, helped preserve veins, and ensured the use of mixed blood. Ampules of the dye solution were obtained from the W. R. Warner Company or made up from dye obtained from the Eastman Kodak Company. Blood volumes were calculated, using centrifuged hematocrits. No correction was made for plasma included in the centrifuged red cell mass.[19] The error of this method is ±175 cubic centimeters.[28] Blood loss at operation was measured by the weighed sponge technique.[44] Accurate records of electrolyte intakes were not maintained, except in those few patients receiving parenteral fluids only for a period before and after operation.

RESULTS

Serum sodium values were below the generally accepted normal values in many of these patients before operation (Fig. 1). The average value for this group of patients was 125 meq. per liter, the range being from 103 to 145 meq. per liter. These findings are in sharp contrast with the serum sodium concen-

*The ossein gelatin used was Knox P 20 type obtained from Knox Gelatine Protein Products, Inc., Camden, N. J.

trations found, using the same technique, in fifty normal blood donors whose levels ranged from 132 to 152 meq. per liter, and averaged 139 meq. per liter. The lowest serum sodium determination, 103 meq. per liter, was seen in a debilitated patient who had carcinoma of the esophagus producing total obstruction. Serum potassium determinations before and after operation were within the normal range in all cases except for two patients who showed abnormally low values (Fig. 2). Both of these patients had carcinoma of the

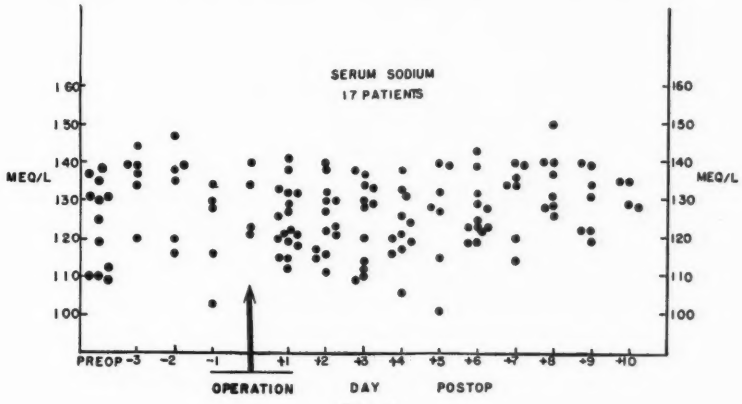

Fig. 1.

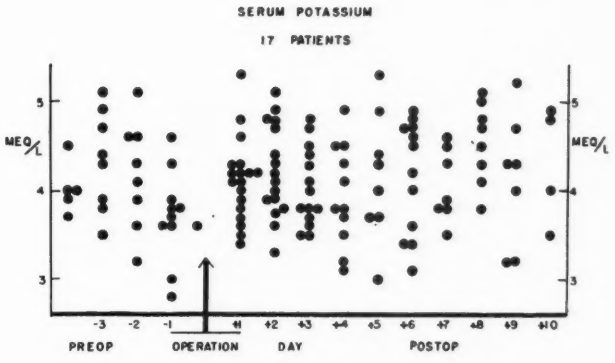

Fig. 2.

esophagus, were severely debilitated, and had received large amounts of intravenous fluids containing inadequate amounts of potassium chloride. Serum chloride concentrations were slightly lower than normal. No significant difference was noted between the pre- and postoperative values (Fig. 3). The average value for the group before operation was 95 meq. per liter. Postoperatively, the level remained about the same, ranging from 110 to 75 meq. per liter.

Changes in the urinary excretion of sodium were marked and consistent (Fig. 4). Before operation the urinary excretion of sodium ranged from 20

to 240 meq. per twenty-four hours. On the day after operation, the excretion of sodium was always depressed, the range being from 1 to 40 meq. per day. Generally, the depression lasted for about five days, and eventually reached the preoperative level by the seventh or ninth day. In all cases in the immediate

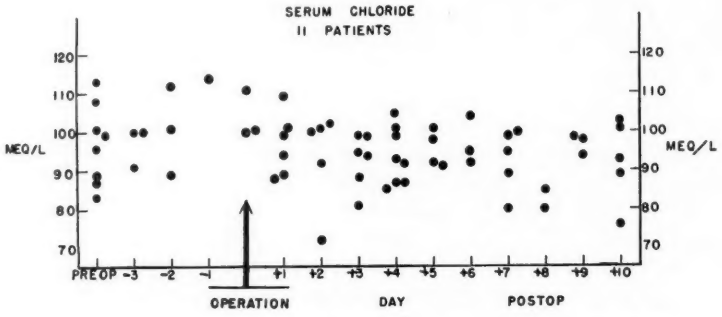

Fig. 3.

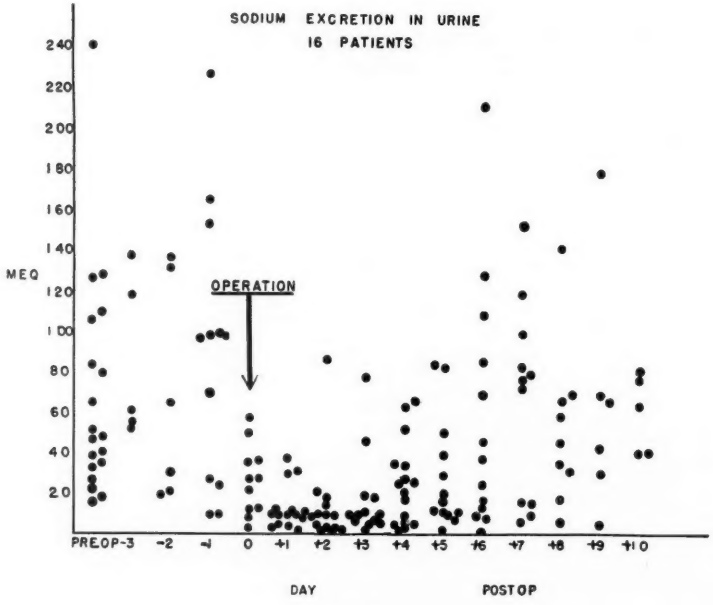

Fig. 4.

postoperative period, the excretion of sodium was less than that of potassium. Urine potassium excretion varied from 10 to 150 meq. per day before operation and there was no significant change in the range of values postoperatively. (Fig. 5). Preoperative chloride excretion ranged from 12 to 230 meq. per day

(Fig. 6). In most cases, the urinary excretion of chloride was diminished during the first three postoperative days. In two patients chloride excretion was unchanged.

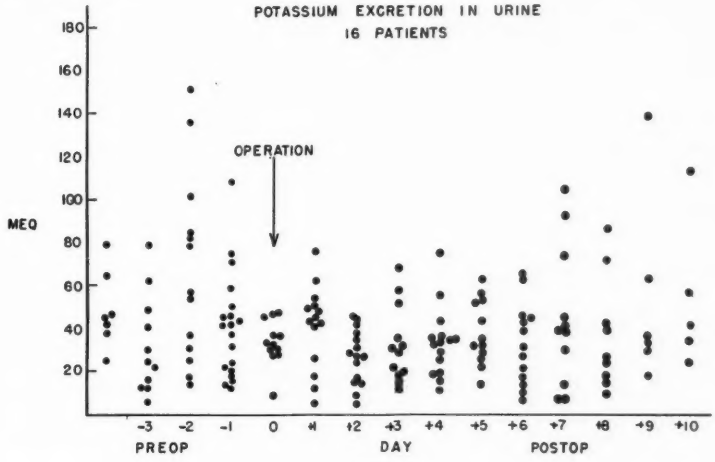

Fig. 5.

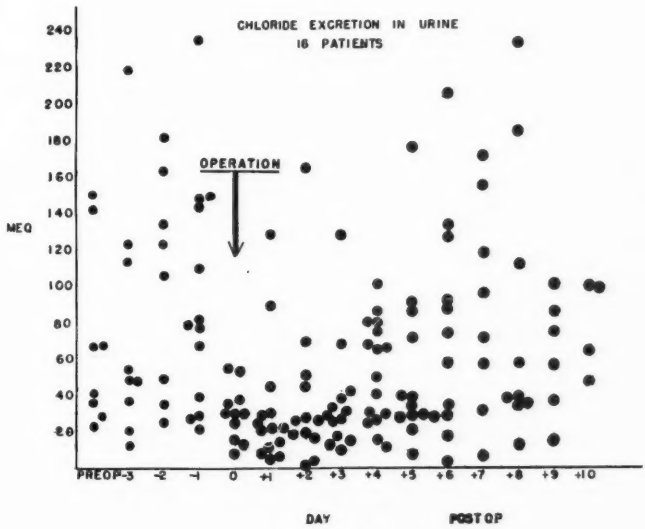

Fig. 6.

In Fig. 7 is shown the average excretion of electrolytes in urine for this group. It can be seen that the sodium excretion was markedly diminished postoperatively; the average figure was 10 meq. during the first twenty-four hours. This depression lasted for five days. The chloride excretion also was

diminished postoperatively, but the average chloride excretion was higher than the average sodium value. Postoperative potassium excretion did not differ significantly from the preoperative average.

The average concentration of the electrolytes in the urine followed the same general trend (Fig. 8). Potassium, however, was excreted in greater

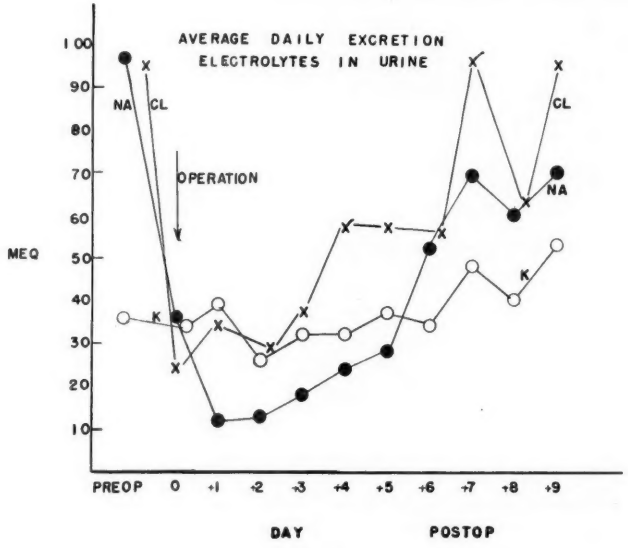

Fig. 7.

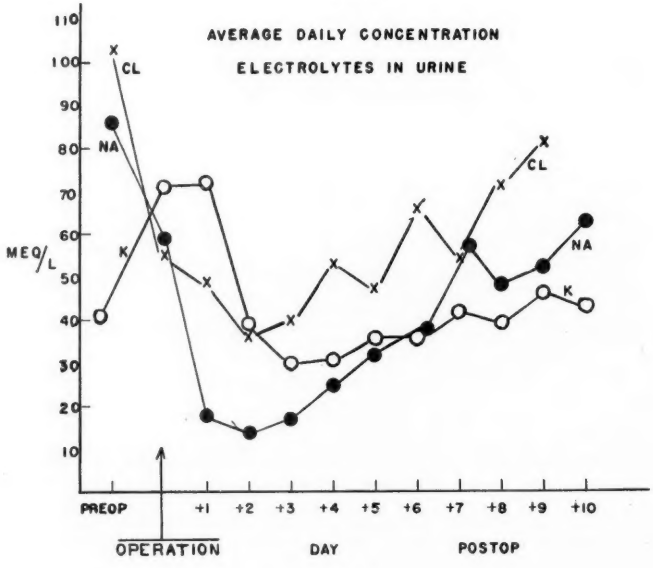

Fig. 8.

concentrations postoperatively than preoperatively. Urine volume decreased slightly postoperatively and therefore the total amount of potassium excreted was about the same before and after operation.

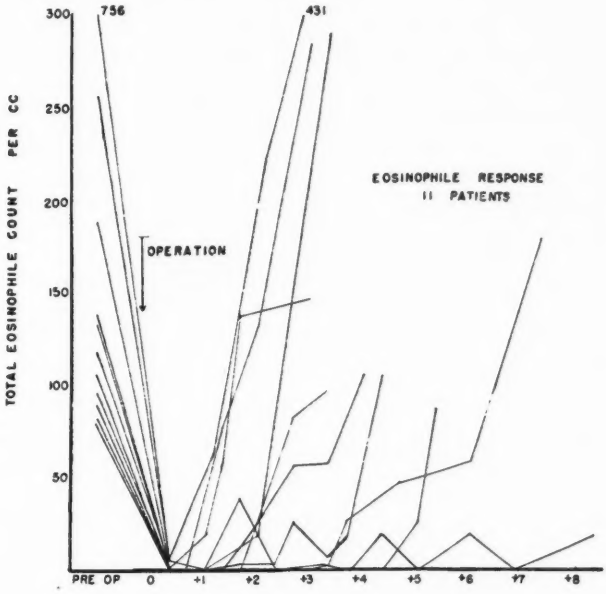

Fig. 9.

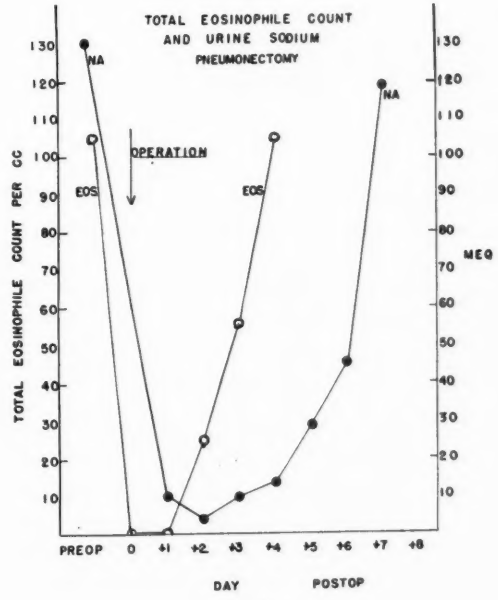

Fig. 10.

Total eosinophil counts were made before and twice daily after operation in 11 patients. The counts fell sharply to six or below after operation in all cases (Fig. 9). A return to normal occurred by the fifth day in all but one patient. This man had a nonresectable esophageal carcinoma and died on the eleventh postoperative day. Depression of the eosinophil count was more prolonged in patients whose clinical condition was poor or who had more severe operations. The response of the eosinophil count to the administration of ACTH was observed in these patients before operation and after the count had returned to normal postoperatively. The response was satisfactory in every case.

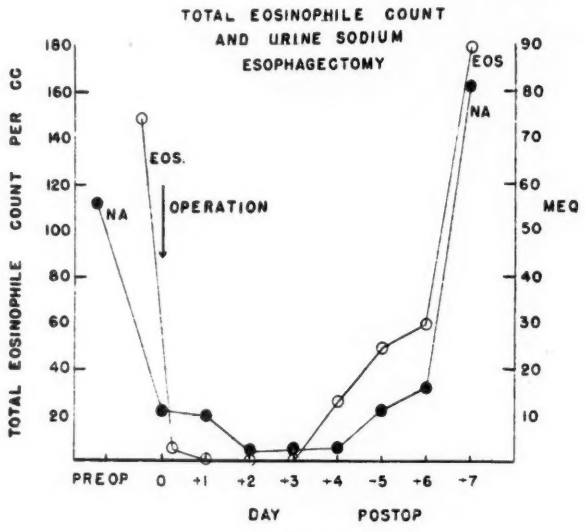

Fig. 11.

In the eleven patients on whom eosinophil counts were done, the return of the eosinophil count and of the sodium excretion to preoperative levels was compared. In six patients the eosinophil count returned to normal much earlier than the sodium excretion. An example of this is seen in Fig. 10. In five patients the eosinophil count followed the sodium excretion. An example of this is illustrated in Fig. 11.

The plasma volume was determined in seventeen patients. It was usually decreased postoperatively in the first eleven patients studied, although blood replacement at operation had been adequate. None of them received plasma or gelatin in the immediate postoperative period. In the last six patients, plasma or gelatin was given to prevent hemoconcentration. The two groups are compared in Fig. 12. Depletion of the plasma volume and hemoconcentration on the first postoperative day can be avoided by the administration of plasma or gelatin during the first twenty-four hours after operation.

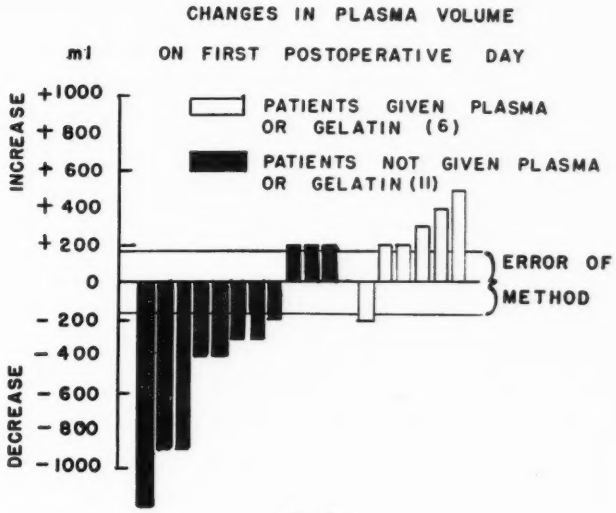
CHANGES IN PLASMA VOLUME
ml ON FIRST POSTOPERATIVE DAY
INCREASE
DECREASE
+1000
+ 800
+ 600
+ 400
+ 200
0
- 200
- 400
- 600
- 800
- 1000
PATIENTS GIVEN PLASMA OR GELATIN (6)
PATIENTS NOT GIVEN PLASMA OR GELATIN (11)
ERROR OF METHOD

Fig. 12.

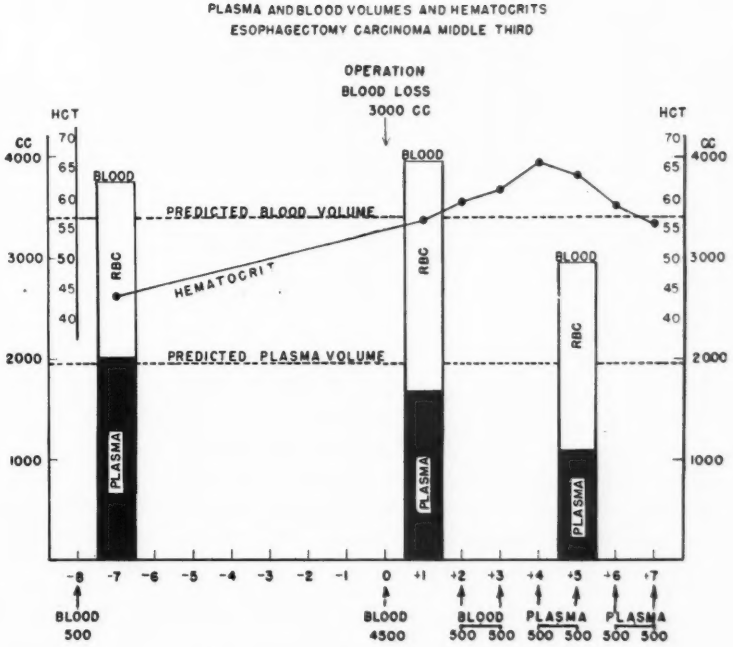
PLASMA AND BLOOD VOLUMES AND HEMATOCRITS
ESOPHAGECTOMY CARCINOMA MIDDLE THIRD
OPERATION
BLOOD LOSS
3000 CC
HCT
CC
4000
3000
2000
1000
70
65
60
55
50
45
40
BLOOD
RBC
PLASMA
PREDICTED BLOOD VOLUME
PREDICTED PLASMA VOLUME
HEMATOCRIT
-8 -7 -6 -5 -4 -3 -2 -1 0 +1 +2 +3 +4 +5 +6 +7
BLOOD 500
BLOOD 4500
BLOOD 500 500
PLASMA 500 500
PLASMA 500 500

Fig. 13.

Three illustrative cases demonstrate this phenomenon. The first case was an esophagectomy (Fig. 13). There was a fall in plasma volume in the postoperative period, with a concomitant rise in hematocrit. This patient was poorly handled in that she received too much blood and no plasma during and immediately after operation. The second patient had a pneumonectomy performed for carcinoma of the lung (Fig. 14). A rise in hematocrit occurred six hours after operation. Following the administration of 1000 ml. of ossein gelatin, the hematocrit fell to normal value. In the third case repeated plasma volume determinations were done (Fig. 15). This patient's initial blood volume was far below the predicted level. He was given 1000 ml. of blood and 300 ml. of plasma before operation. This resulted in a return of his blood and plasma volumes to approximately their predicted normal values which were maintained in the postoperative period.

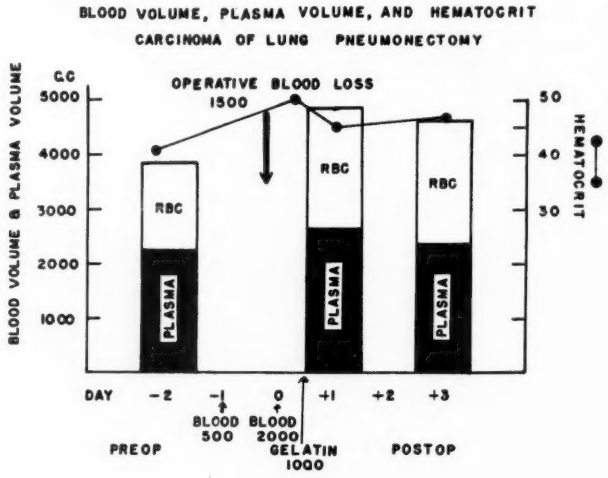

Fig. 14.

DISCUSSION

The low serum sodium levels in this group of patients, both pre- and postoperatively, was an unexpected finding. The cause of the hyponatremia is not clear. Sims and associates[40] have reported asymptomatic hyponatremia in a group of ten patients with chronic pulmonary tuberculosis. In their group of patients, administration of sodium chloride resulted in increased urinary excretion of sodium. On the other hand, when sodium was withheld, urinary excretion diminished. Neither increasing nor decreasing the sodium intake changed the concentration of sodium in the serum. These authors contrasted their findings with those observed in adrenal cortical insufficiency in which urinary sodium excretion continues in the face of low serum levels and low sodium intake. They attributed the findings to a primary intracellular hypoosmolarity with final adjustment of all electrolyte levels at a lower concentra-

tion. That adrenal insufficiency is probably not the cause of the hyponatremia in our patients is indicated by the normal response of the eosinophils to the Thorn test and to the trauma of operation and by the uniform decrease in the urinary excretion of sodium after operation. With one exception, we did not administer large amounts of sodium in the postoperative period to our patients. In one patient who received large quantities of sodium chloride in isotonic solution ofter operation, the urinary excretion of sodium and the serum sodium level

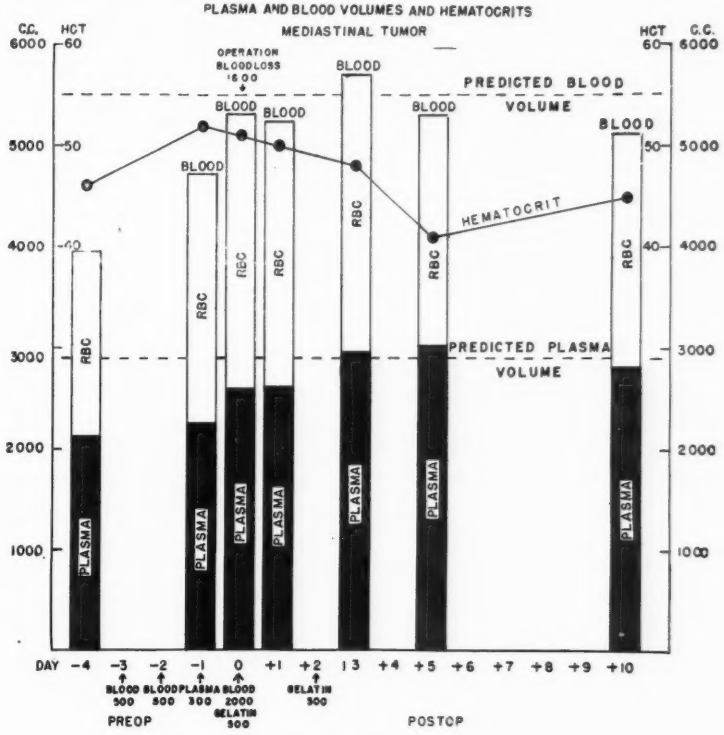

Fig. 15.

remained low (Fig. 16). By the fourth postoperative day, this patient had retained almost 1000 meq. of sodium. Water was retained in proportionate amounts so that approximately one liter was added to the body fluids for each 112 meq. of sodium. This undesirable result of administering large amounts of sodium chloride in the immediate postoperative period has been well shown.[2, 7, 8, 9, 31]

Only two patients in this series had low serum potassium levels. Both patients had carcinoma of the esophagus, were severely debilitated, and had received parenteral fluids for long periods of time. They did not exhibit the typical clinical picture of hypopotassemia, nor did they show electrocardio-

graphic changes. The published reports describing potassium deficits in surgical patients concern patients who have lesions of the gastrointestinal tract.[5, 22, 27, 36] Most of the patients in this group were able to take food by mouth early in the postoperative period. Therefore, one would not expect potassium deficiencies to develop.[12] The serum chloride concentrations generally were within the normal range. The patients who had low serum chloride values also had low serum sodium and often low serum potassium values.

The diminished excretion of sodium after operation was striking. The relation of this decreased sodium concentration to increased secretion of the desoxycorticosterone-like hormones of the adrenal cortex has been shown by the studies of Conn, Hardy, Johnson and associates, Leaf and Couter, and Thorn.[10, 11, 20, 23, 25, 41] It has been pointed out that the 11-oxysteroid hormone of the adrenal cortex influences the number of circulating eosinophils.[42]

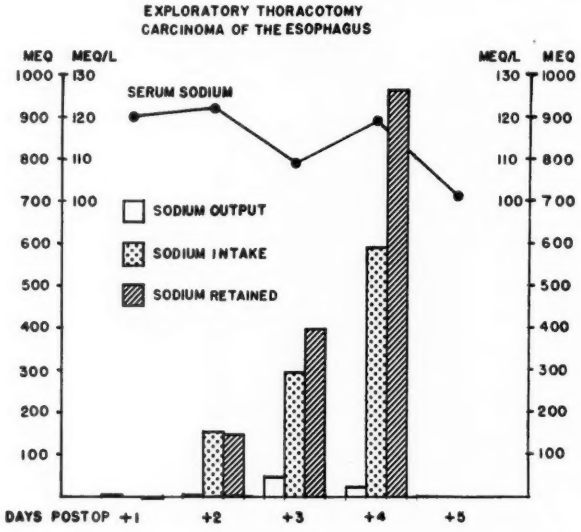

Fig. 16.

Moore[29] has pointed out that these urinary electrolyte changes probably represent a normal protective mechanism. In the majority of the cases reported here, urinary sodium excretion did not reach preoperative levels until the sixth postoperative day. In sharp contrast to sodium excretion the urinary excretion of potassium was not diminished postoperatively. The increased urinary excretion of potassium reported by others was not observed.[5, 22, 27, 36]

Much interest has been shown in the relationship of excretion of sodium and chloride in the urine of surgical patients. VanSlyke and Evans[43] used the Fantus test[14] for urinary chloride concentration as a guide in the administration of sodium chloride, but warned that reliable results could probably not be ob-

tained in the immediate postoperative period. That there is frequently marked difference in the total urinary excretion of sodium and chloride, particularly when acid base balance is disturbed, has been emphasized by Randall and associates.[37] They have shown that dependence upon urinary excretion of chloride alone may lead to serious errors in administration of sodium chloride. In half our patients after operation, there was good correlation between urinary excretion of sodium and chloride. In the remainder, more chloride than sodium was excreted.

The response of the total eosinophil count to the administration of ACTH and the trauma of operation as an indication of the adequacy of function of the adrenal cortex was proposed by Thorn and associates.[42] Hardy[20] showed close correlation between the eosinophil response and the changes in urinary excretion of sodium while Johnson and co-workers[23] have demonstrated the dissociation of these. This dissociation has been emphasized by Moore,[30] and is important because the return to normal of the eosinophil count does not necessarily mean resumption by the kidneys of normal excretion of sodium. This was demonstrated in a number of our patients.

The importance of blood volume determinations in seriously ill surgical patients has been pointed out.[1, 6, 26, 32, 35] In our early cases, blood volumes were determined before and after operation to ensure that preoperative transfusions were adequate and operative blood loss had been properly replaced. A diminution in the plasma volume postoperatively was observed, even though the blood lost at operation had been replaced. The serosanguinous pleural effusion occurring after thoracotomy, as well as the loss of fluid into traumatized areas, is probably sufficient to account for the diminished plasma volume. Plasma or gelatin was given to the later cases after operation to replace this plasma loss and avoid hemoconcentration.

SUMMARY

1. Nineteen patients subjected to major intrathoracic operations were studied. Urine and serum sodium, potassium, and chloride concentrations were determined. Plasma volumes and hematocrits were measured and blood volumes calculated. Total eosinophil counts were made in eleven patients.

2. The preoperative serum sodium concentration was usually low, averaging 125 meq. per liter. Little change was observed after operation. Serum potassium and serum chloride did not show significant deviations.

3. Urine sodium excretion was depressed postoperatively, usually to less than 10 meq. per day. This depression lasted for about five days. Urine chloride excretion also was depressed postoperatively, but not to the same extent. The urinary potassium excretion showed no significant change after operation.

4. There was no evidence of adrenocortical insufficiency in any of these patients.

5. After operation, diminished urinary excretion of sodium persisted longer than depression of the total eosinophil count in half of the patients so studied.

6. Diminution of the plasma volume and increase in the hematocrit was noted during the first twenty-four hours after operation, unless plasma or a plasma substitute (ossein gelatin) was administered.

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DISCUSSION

DR. JOHN H. GIBBON, Jr., Philadelphia.—There are certain results of major operations which follow operation upon the chest, as well as the abdomen or any other part of the body, and one such result is this rather strikingly diminished urinary excretion of sodium postoperatively. We have a series of seventeen cases in which this has occurred in every case. The depression of the urinary excretion of sodium lasted about five days. Most of these seventeen patients were subjected to very prolonged operations. I think it is important to realize that following long operations, the diminished urinary excretion of sodium may last as long as five days. Another finding which we encountered was the low level of serum sodium before operation which was unchanged after operation. This has been previously reported in a small number of cases in patients with chronic tuberculosis. We do not know the explanation for this hyponatremia, but we do know that if you try to raise the low serum sodium level in the immediate postoperative period by administering large quantities of physiologic salt solution, sodium and water accumulate in the body, the urinary excretion of sodium increases only slightly, and the concentration of sodium in the serum is unchanged.

Finally, we have found, as many of you have probably also, that one does not learn a great deal from total eosinophil counts. In general, total eosinophil counts, if they bounce up promptly after a major operation, indicate that the patient is getting along pretty well. If they stay down, it probably is an indication that the patient has received severe trauma and is not in good condition. But, it should be emphasized, the depression of the total eosinophil count does not necessarily parallel the depression of the renal excretion of sodium. It would appear to us that you can regard the eosinophil count as a measurable effect of the 11-oxysteroids of the adrenal cortex, whereas the electrolyte effects are due to the desoxycorticosterone-like hormones, and it is this group which affects the fluid and electrolyte balance postoperatively. You will not necessarily obtain an indication of the activity of the latter hormones from total eosinophil counts.

COMPLICATIONS AND SURGICAL TREATMENT OF HIATUS HERNIA AND SHORT ESOPHAGUS

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HIATUS hernia is not thought of as a fatal or even an incapacitating disease. There is a popular concept that this is an innocuous ailment capable only of dyspepsia and other trivial symptoms. Actually this idea is as erroneous as it is widespread. In reality the symptoms of hiatus hernia may be distressing, but the complications of the hernia are serious and occasionally fatal.

Consideration of the complications associated with hiatus hernia is important in recognizing the indications for surgical repair. Esophageal hiatus hernias are observed more commonly with improving diagnostic techniques. Brick[1] has pointed out that the incidence of hiatus hernia among patients undergoing roentgen examination of the upper gastrointestinal tract is approximately 9 per cent. The incidence may prove to be higher in the future. Recognizing the increasing frequency with which true hernias are seen, it becomes more important to develop a sound method of evaluation for therapy. A distinction between the symptoms and complications of hiatus hernia will be helpful in selecting treatment suited for the individual case.

Hiatus hernia is commonly classified into three main groups:[2]

1. The paraesophageal hernia.
2. The pulsion type hernia.
3. The short esophagus with thoracic stomach.

We believe that a sharp distinction must be made between true hernias of the paraesophageal or pulsion type and the thoracic stomach associated with short esophagus. This distinction is based on our belief that the etiology differs between the two groups as do the related symptoms, complications, and clinical course. For clarity the two groups will be presented separately.

COMPLICATIONS OF HIATUS HERNIA

Whereas the symptoms of true hiatus hernia are extremely variable in character and degree, the complications are rather clearly defined; for the most part we can classify them under three major headings: (1) bleeding; (a) occult or massive, (b) hematemesis or melena; (2) peptic ulcer; (3) volvulus.

Bleeding: In all probability this is the most common complication of hiatus hernia. Much has been written on this subject, calling attention to the

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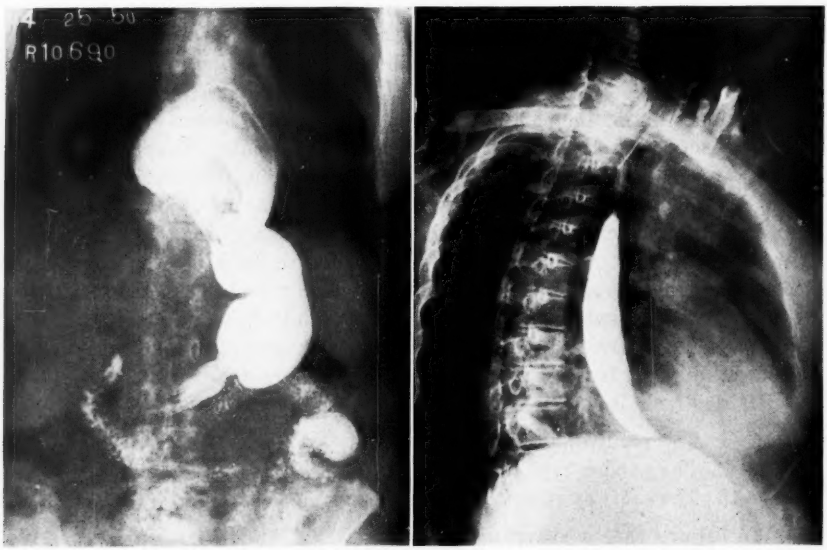
"blood loss" anemia, fatal hemorrhage, intermittent hematemesis, and melena attributable to hiatus hernias.[3-7] Theories as to the cause of the bleeding have included erosion of gastric mucosa associated with venous congestion, gastric varices, peptic ulcer, esophagitis, and intestinal defects secondary to the impaired gastric physiology.[7, 8] Regardless of the causes, bleeding is a frequent and troublesome complication of hiatus hernia. It may be occult in character and manifested only by "blood loss" anemia; on the other hand, there may be massive bleeding without premonitory signs. Hemoglobin determinations of less than 6.5 Gm. are not uncommon among this group of patients. It may be pertinent that hemorrhage does not seem related to the size or shape of the hernia.[6]



A. *B.*

Fig. 1.—*A*, Hiatus hernia associated with volvulus manifested by upper gastrointestinal obstruction. The patient was a 61-year-old woman with progressive increase of symptoms over a ten-year period. *B*, Postoperative barium study one year after operation; complete relief of all symptoms.

Peptic Ulcer: True peptic ulcer has been recognized for many years as a complication of hiatus hernia.[9] The cause of the ulcer has been attributed to erosion, trauma, retained acid secretions, and other factors. Ulcers may

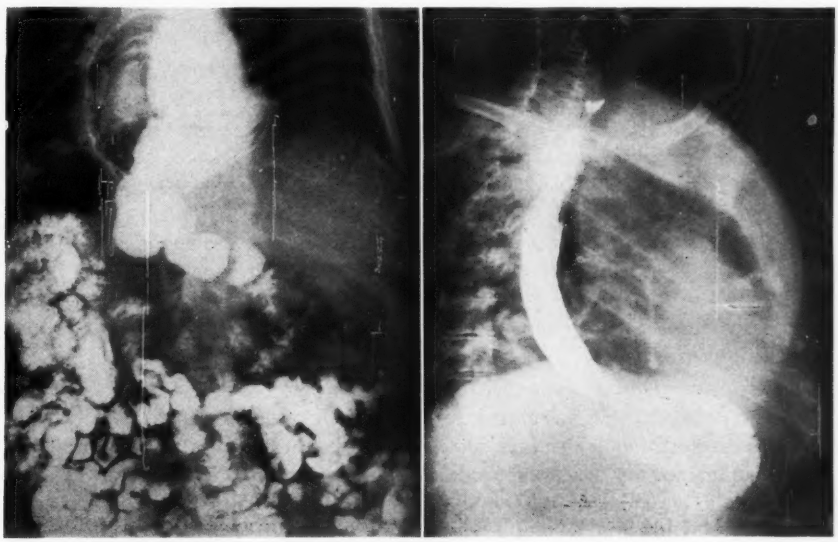
TABLE I*

	NO. OF PATIENTS
Hematemesis	7
Melena	9
Blood loss anemia (below 11 Gm.)	14
Critical blood loss (below 7 Gm.)	5

*Of the 36 patients operated upon for hiatus hernia, 14 manifested complications by bleeding. Accurate evaluation is difficult as all patients received supportive therapy before transfer to the Cleveland Clinic.

be difficult to demonstrate by barium studies; likewise, their response to medical therapy is difficult to evaluate. Bleeding from these ulcers is common; perforation is not, although it usually has been reported as fatal.[10]

Volvulus: This term is broadly used to include twisting or folding of herniated stomach within the mediastinum. For simplicity we have included incarceration with obstruction under this heading, although true volvulus need not be a factor. Usually this complication is manifested on the roentgenogram by two or more fluid levels in the herniated segment.[11] Occasionally it is demonstrated by herniation of the antrum with the fundus and pylorus seen below the hiatus. Clinically these patients are more inclined to vomiting, pain, and dysphagia.[12-14] We have not seen strangulation of the incarcerated segment, although it has been reported.[11]



A. *B.*

Fig. 2.—*A*, Large paraesophageal hiatus hernia complicated by volvulus and severe bleeding; symptoms present twenty-one years. On admission to hospital hemoglobin was 6.2 Gm. *B*, Postoperative roentgenogram eight months after surgery; complete relief of symptoms. Hemoglobin 13.4 Gm.

Comment: By no means are all complications of hiatus hernia included in this classification. The overwhelming majority, however, will fall into one or more of the three categories.

Many of the voluminous reports found in the literature discuss briefly the subject of treatment or indications for either medical or surgical approach. Frequently encountered is the suggestion of correlation between the size of the hernia and severity of symptoms. We do not believe that such relationship exists; nor do we feel that size alone is an indication of the type of treat-

ment. A small hernia may be reponsible for an exsanguinating hemorrhage, whereas a much larger hernia may produce nothing more than occasional eructation.

Specific indications for surgical repair of hiatus hernia will always be variable. Careful evaluation of the patient, however, with distinction between symptoms and complications, will assist in election of either medical or surgical therapy. We believe that the presence of one or more of the complications listed is an indication for surgical repair.

COMPLICATIONS OF SHORT ESOPHAGUS

The symptom complex produced by short esophagus with thoracic stomach may parallel that of hiatus hernia. The problem of differentiation between the two lesions is well known. As might be expected, there is a similarity in the range of complication.

Again we have stressed three separate categories of complications attributable to short esophagus. These are: (1) stricture; (2) bleeding: (a) occult or massive, (b) hematemesis or melena; (3) peptic ulcer: (a) gastric or esophageal, (b) penetrating or perforating.

Stricture: Dysphagia is the most common symptom associated with short esophagus, and in itself is not a complication. In advanced cases, particularly those associated with esophagitis or peptic ulcer producing cicatricial contracture, a fibrotic stricture may be produced that resists all efforts by bouginage and medical therapy.[15, 16] Severe pain and chronic inanition, secondary to the stricture, may render the patient a gastrointestinal cripple. In such cases differential diagnosis between carcinoma and inflammatory stricture may be impossible.

Bleeding: This is a common manifestation and may occur in the variety of ways demonstrated in hiatus hernia.[15, 17] In short esophagus, however, there is an additional bleeding source found in the terminal esophagus. The severe inflammatory changes produced by long-standing esophagitis greatly increase the vascularity of the involved segment. The diseased mucosa is friable and hyperemic, bleeding readily with minimal trauma. Chronic "blood loss" anemia is a common finding in these patients; recurrent episodes of hematemesis and melena are not infrequent.

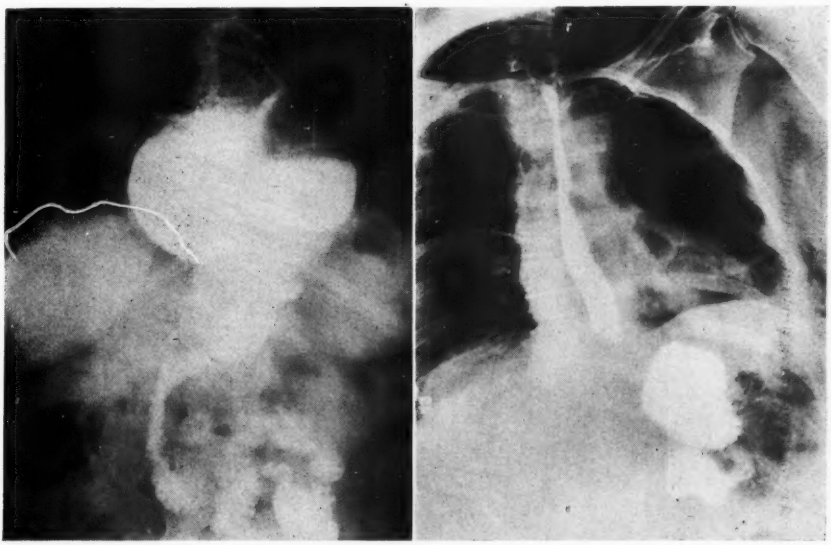
TABLE II*

	NO. OF PATIENTS
Blood loss anemia (below 11 Gm.)	7
Critical blood loss (below 7 Gm.)	4

*Seven of the 16 patients operated upon for complicated short esophagus had episodes of bleeding.

Peptic Ulcer: The association of ulcer with acquired short esophagus has been known for many years. Johnstone, Allison, Dick, and others[18-20] have commented on the severity of the symptoms and the resistance to conservative therapy.

Peptic ulcer may occur as either the initiating factor or as the secondary complication of short esophagus. With severe gastritis and esophagitis, accurate localization by radiographic and endoscopic means is difficult. Although these ulcers have been considered esophageal in origin, findings at operation suggest that they arise more commonly in the cardia of the thoracic stomach. In three of our cases the ulcers had perforated into the mediastinum; one sealed perforation involved the pericardium; another had penetrated the medial segment of the right lower lobe.



A. *B.*

Fig. 3.—*A*, Large paraesophageal hiatus hernia with extreme volvulus and anterior displacement of esophagus. The patient was a 66-year-old white woman who complained of pain and vomiting associated with ingestion of food. Patient was addicted to paregoric. *B*, Postoperative appearance fourteen months after surgery; complete relief of all symptoms.

Comment: Symptomatic short esophagus is a structure deformity. In the complicated cases conservative treatment has, in many instances, proved inadequate. It may be also impossible to exclude carcinoma by radiographic studies or esophagoscopy. The generally unsatisfactory response to conservative measures, plus the uncertainty of diagnosis, have prompted more radical approaches in selected cases. Consideration of the factors complicating this disease will aid in the selection of candidates for surgery.

SURGICAL TREATMENT

Hiatus Hernia: Thirty-six patients with paraesophageal or pulsion type hernia have been operated upon; recovery has been complete and uneventful in all cases. Each patient manifested one or more complications of hiatus

hernia, the presence of the complication having been considered an indication for surgery. Although sufficient time has not elapsed to permit accurate evaluation of indications or techniques employed, the immediate results are uniformly good. All patients have been relieved of symptoms attributed to the hernia, and there have been no recurrences.

A simple technique of surgical repair has been used in these cases, employing the transthoracic approach. In many respects our concept of the hernia and its repair is in accord with the ideas expressed by Allison.[22] How-

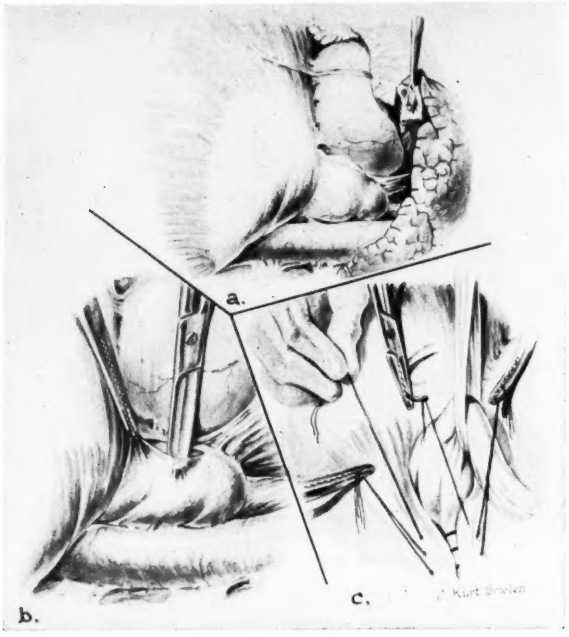


Fig. 4.—*A*, Artist's description of operative field through thoracic approach. *B*, Beginning of mediastinal dissection with incision of mediastinal pleura. Mobilization of esophagus and thoracic stomach is best accomplished by sharp dissection. *C*, Interrupted sutures to approximate the right and left crura are carefully placed after mobilization and dissection are completed.

ever, we have attached greater significance to permanent reduction of the stomach below the diaphragm and less to the so-called sphincter action of the hiatus. A brief description of the operative technique follows:

Endotracheal anesthesia is employed; the patient is placed in a lateral position. The thoracic incision is made over the eighth rib. The mediastinal pleura is incised from the hiatus through the pulmonary ligament to the inferior pulmonary vein. By sharp and blunt dissection the herniated segment and the terminal esophagus are mobilized. The fascia and reflected peritoneum are transected over the hernia and the crura freed by sharp dissection. The

retroperitoneal portion of the stomach is gently dissected away from the posterior aspect of the hiatus. After carefully placing the sutures, the right and left crura are approximated posteriorly to the esophagus. The hiatus is closed snugly around the esophagus. A 16 French stomach tube is left in place for twenty-four hours. The phrenic nerve is not disturbed.

Short Esophagus: The need for a definitive surgical procedure in the treatment for short esophagus is evident. Ideally, this procedure should be simple and adaptable to all variations of the disease. The pathologic variations produced by short esophagus, however, have forced us to subdivide the entity and its therapy into two groups: (A) ulcerated short esophagus, (B) simple short esophagus.

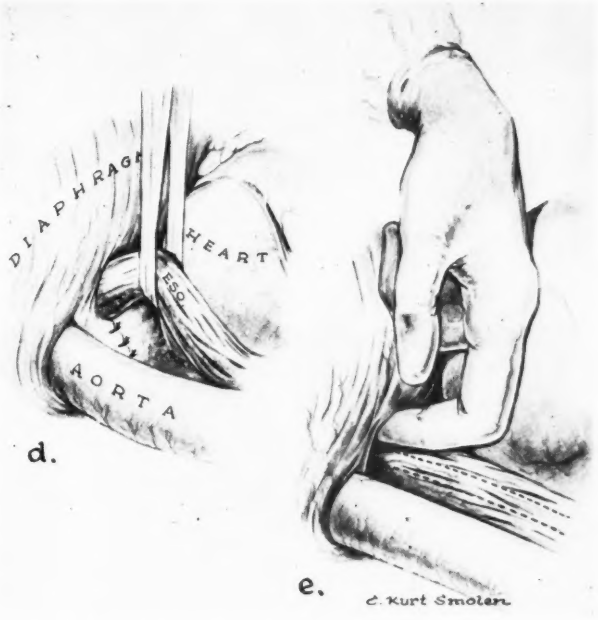


Fig. 5.—*D*, Appearance of operative field at completion of operation. The diaphragm is not paralyzed. *E*, A gastric tube is left in place for twenty-four hours. The operator's index finger examines the hiatus to assure complete closure.

Group A is made up of the cases with extensive shortening, severe periesophagitis, peptic ulcer with penetration, and secondary changes in the surrounding mediastinum. Radiographic studies in this group resemble those of extensive malignancy, and differential diagnosis may be exceedingly difficult. These patients respond poorly, if at all, to conservative measures.

Surgical therapy in this group is a difficult and occasionally hazardous undertaking.[16] The mediastinum surrounding the diseased area is altered by the chronic inflammation. Increased vascularity and fibrosis render the dis-

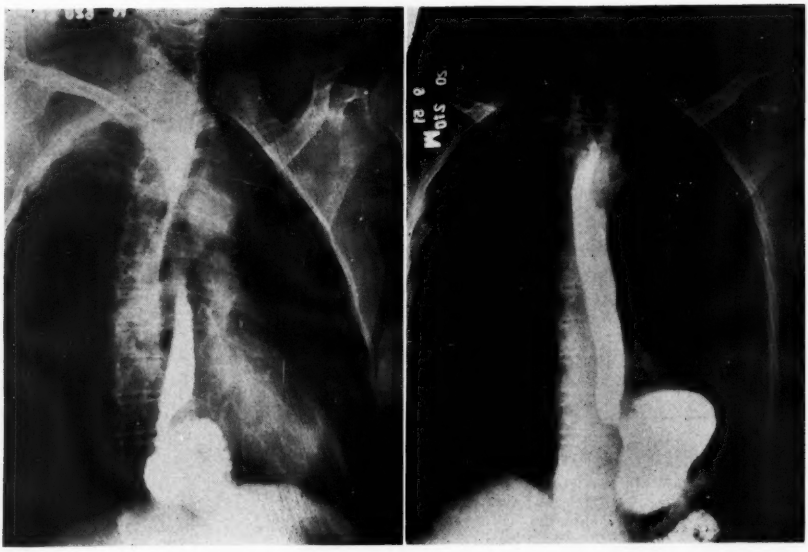


Fig. 6.—*A*, Short esophagus and thoracic stomach in a 60-year-old white woman manifesting severe pain and intermittent obstruc ion. *B*, Roentgenogram made two months after surgery, illustrating the reduction of stomach within the abdominal cavity. Complete relief of symptoms.

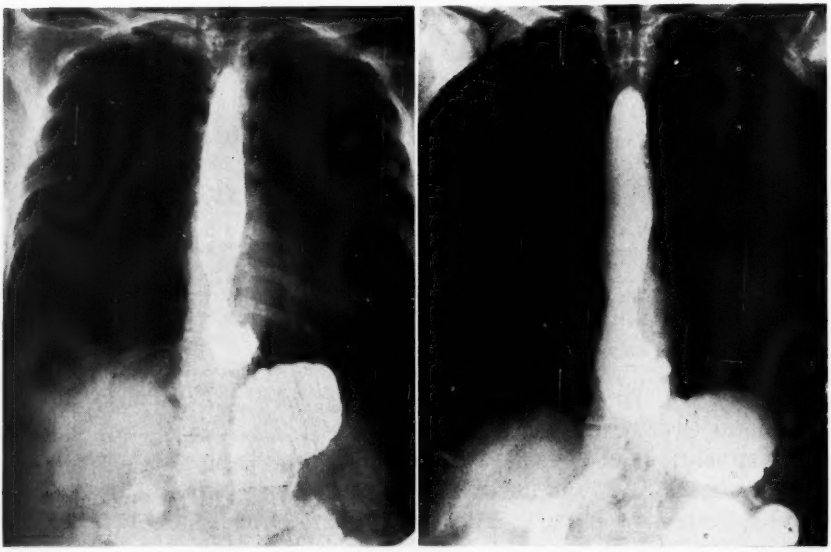


Fig. 7.—*A*, Short esophagus complicated by gastric ulcer in a 55-year-old white woman. Immediate relief following surgical correction without resection. *B*, Short esophagus with thoracic stomach complicated by a large gastric ulcer in a 55-year-old white man believed to have acquired esophageal shortening.

section most tedious. In essence, the surgical treatment of the severely ulcerated short esophagus is similar to that of carcinoma. The diseased segment is resected and continuity is restored by esophagogastrostomy. We have employed this procedure in only six cases; all of the patients were benefited.

The second group includes patients having a short esophagus who have not suffered the severe structural changes which characterize Group A. Whereas one or more of the complications previously discussed may be present, the patient is not reduced to the status of an invalid. Nevertheless, these people require constant therapy and clinical observation as long as the short esophagus remains. The usual medical therapy abetted by bouginage may alleviate but not cure the disease.

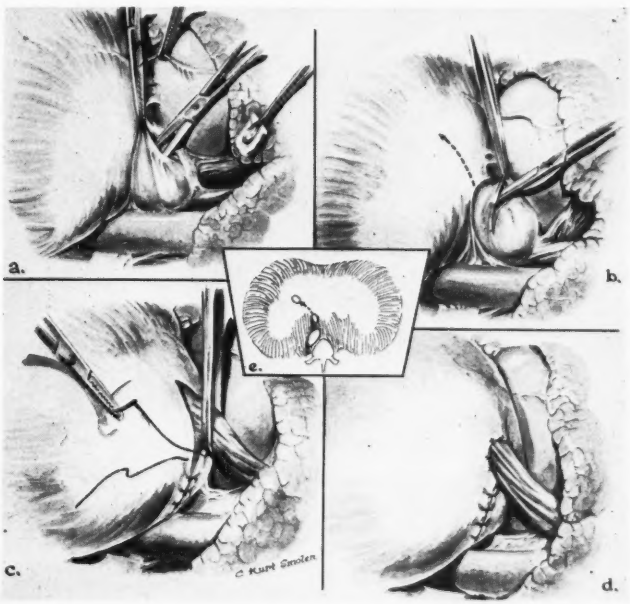


Fig. 8.—Technique of thoracic correction of simple short esophagus. *A*, Interruption of the phrenic nerve and mobilization of thoracic stomach with terminal esophagus by sharp dissection. *B*, Incision of phrenoesophageal fascia and reflected peritoneum over the thoracic stomach. The dotted line illustrates the radial incision through the paralyzed diaphragm. *C*, Posterior approximation of crura following reduction of thoracic stomach. *D*, A completed operation illustrating displacement of esophagus to new hiatal opening at high portion of paralyzed diaphragm. *E*, Diagram illustrating transplanted esophageal hiatus.

Surgical measures for short esophagus have been rather limited. Phrenic nerve crush, gastrostomy, vagotomy, enlargement of the esophageal hiatus, and other procedures have been used with indifferent results. It is not illogical to presume that relief of symptoms and prevention of future complications would depend upon correction of the primary structural abnormality. In other words, unless the stomach has been permanently reduced below the diaphragm and the esophagus of sufficient length to span the vertical diameter

of the thorax, the underlying problem remains the same. A simple operation has been employed for the past two years in a group of ten patients with short esophagus. The technique is similar to that described by Merendino, Varco, and Wangensteen[21] in the treatment of hiatus hernia. The results have been uniformly good; there have been no failures and no surgical complications. Description of the technique follows:

A thoracotomy incision is made over the eighth rib. The mediastinal pleura is incised; the thoracic stomach and terminal esophagus are carefully mobilized. The phrenic nerve is divided for permanent paralysis of the diaphragm. At this point the surgeon will observe noticeable elevation of the

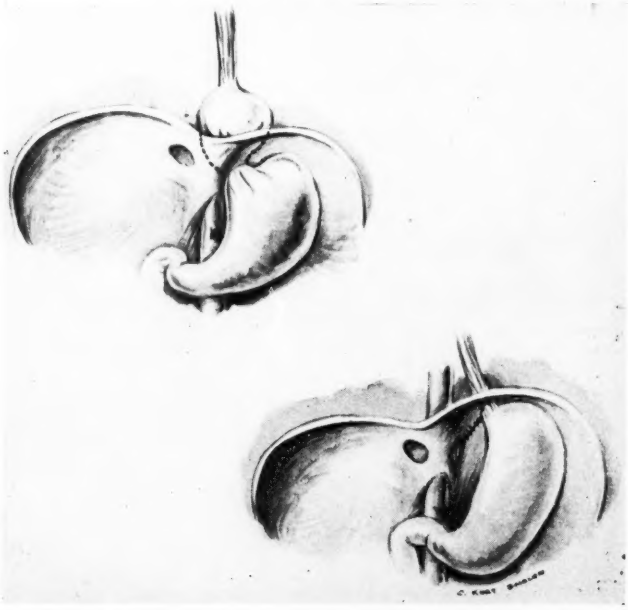


Fig. 9.—Schematic correction of simple short esophagus by permanent paralysis of the left diaphragm and transplantation of esophagus to new hiatus. The short esophagus is not appreciably lengthened, although the thoracic stomach is reduced below the diaphragm.

tendinous dome; the hiatus is not appreciably altered in size or position. The site of the "new" hiatus is selected at the dome of the diaphragm and a radical incision made to the esophagus. If mobilization is adequate, the tendinous leaves can be elevated to the cardiac esophagus, reducing the thoracic stomach to the abdominal cavity. The "old" hiatus is closed by approximating the crura. The terminal esophagus is carefully tacked with silk mattress sutures to the tendinous diaphragm to prevent sliding. With this procedure the esophagus is not elongated to a significant degree; in reality the abdominal cavity is lengthened and thoracic space is shortened. In reducing the distance traversed by the thoracic esophagus a former short esophagus may now be adequate in length.

CONCLUSION

Hiatus hernia may be a serious, incapacitating disease. Surgical correction is not difficult and offers possibility of cure.

Short esophagus is a disease characterized by annoying symptoms and capable of serious complications. Unless the structural defect is corrected permanently, any other form of therapy must be considered as merely palliative. Two methods of surgical treatment are suggested.

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DISCUSSION

DR. FORRESTER RAINE, Milwaukee, Wis.—I began, some five years ago at the Veterans Hospital at Wood, Wisconsin, seeing every patient with a diagnosis of short esophagus and hiatus hernia. I had planned to write a paper on the subject, but I found each year that I knew less than I did the year before and, as a result, have not gotten to it yet.

In all, we have seen eighty-nine patients with a short esophagus and hiatus hernia. Of this group, 50 per cent were so nearly symptomless that no treatment was considered. In the remainder we have the various types of complications that Dr. Effler has talked about. Some of them have a relatively minor stricture, and those we have been able to manage only by dilatation and medical ulcer management. Others have had so much stricture that it could not be overcome by dilatations; they had peptic ulcers at the junction (mos tof those I have seen have been at the junction of the esophageal gastric mucosa rather than in the gastric pouch itself) and some type of resection had to be done. I have also found that there is a very high percentage of associated duodenal or gastric ulcer with the short esophagus cases that have an ulcer and a stricture, and these we have elected to handle by doing a gastric resection with repair of the hernia. I am sorry to say that in my hands none of these procedures have been entirely successful. We have had esophageal ulceration or esophagit's continue after gastric resection, so that we have had a very difficult time feeding them.

The associated vagotomy with resection I feel is some protection against recurrent ulceration at the anastomosis, and that has not as yet occurred in any of our cases. I thought that it might be interesting to show a patient who, I think, demonstrates very well the terrific pull of the inflamed esophagus and how it can shorten and pull a narrow tube of stomach up into the chest.

(Slide.) Here you see a patient who came in with a massive hemorrhage, a duration of four or five years' difficulty in swallowing, and I think you can see the height of the stricture and the ulceration present at the point of stricture.

(Slide.) This shows the patient after he had been treated by dilatation and ulcer diet, and there is much less spasm, and the narrowed area has come down far closer to the diaphragm. Repeated dilatations, however, failed to control him, and finally resection was done.

(Slide.) I think you will also notice the difficulty I have had with him afterward, that is, the amount of gastric retention which is associated with vagotomy. This has been a troublesome feature in some of these resections.

(Slide.) This is a somewhat different type which I think shows some of the difficulties in differential diagnosis between achalasia, carcinoma, and a short esophagus. This is a picture of a short esophagus with ulceration at the junction, rather than early achalasia or carcinoma.

DR. ALTON OCHSNER, New Orleans.—There is no question that many of these patients will require resection. It is of interest to me that when one resects for short esophagus, one leaves an esophagus which is even shorter than before, yet with very few exceptions the results are good after the resection.

Several years ago before this Association I mentioned a patient who had a short esophagus with ulceration, in whom we advised a resection. This patient, an elderly woman, refused resection and, on the advice of one of the younger house officers, we did a phrenicectomy. The patient was promptly relieved of her symptoms and has remained well. Since that time we have done an increasing number of phrenicectomies in these individuals. I am inclined to believe that unless there is considerable damage, the symptoms can be relieved by phrenicectomy, and probably the symptoms in the short esophagus, when they have symptoms, are due to the pull of the diaphragm upon the segment of stomach which is herniated into the thoracic cage.

DR. LAMAR SOUTTER, Boston.—I think that Dr. Effler's paper was very good, particularly in demonstrating variations in technique to suit the length of the esophagus. Several surgeons at the Massachusetts General Hospital have employed a somewhat similar technique with good results. In some ten cases, we have deliberately made an opening in the tendinous portion of the diaphragm sufficiently large to permit the hand to enter the abdominal cavity. This permits exploration of the upper abdomen in an effort to determine the presence or absence of peptic ulcers and gall bladder disease. It is helpful in ascertaining that the stomach has been completely reduced. It is most valuable in permitting accurate placement of the

sutures in the diaphragm by bimanual palpation. For those patients with poor crurae posteriorly or with a true short esophagus, the incision can be extended and the esophagus transplanted anteriorly in the manner which Dr. Effler has shown. We have felt that this approach has made the surgery of diaphragmatic hernias easier and more effective. It has not compromised the diaphragmatic muscle nor increased the postoperative morbidity.

DR. EFFLER (closing).—I would like to thank Dr. Raine, Dr. Ochsner, and Dr. Soutter for their kindness in discussing this paper. In reference to the ulcerative or complicated form of short esophagus, I must admit that my own experience is brief, encompassing a period of only two and one-half years. Six of these patients have been treated by resection and esophagogastrostomy. I agree with Dr. Raine and Dr. Ochsner that this is substitution of one disease for another. Dr. Ochsner has suggested that a phrenic crush might be of value in such a patient when pain is the predominant factor. Three of the six patients mentioned above had previous phrenic operations and had transient relief or none at all. It is also worthy of mention that two of the six patients were addicted to codeine or morphine, and two others were in the habit of using large amounts of paregoric. Perhaps the most important argument in favor of primary resection is the difficulty of differentiation between peptic ulcer and primary carcinoma.

As Dr. Raine mentioned, the secondary vagotonic stomach may be a serious problem in patients treated by primary resection. Two of our patients required further surgical assistance following esophagogastrostomy.

Whereas our experience is limited, we are, nevertheless, very optimistic that correction of the simple type of short esophagus with thoracic stomach may prevent the development of future complications associated with severe esophagitis, mediastinitis, and ulceration. We believe that this simple operative correction may well prevent the necessity of primary resection and esophagogastrostomy at a later date.

FORMATION OF A TEMPORARY EXTERNAL ESOPHAGEAL FISTULA OVER A T-TUBE FOR STENOSING ESOPHAGITIS

PHILIP THOREK, M.D. (BY INVITATION)
CHICAGO, ILL.

STENOSING esophagitis with or without perforation is not a rare condition. Although the etiology is uncertain, the most probable cause is the effect of gastric juice upon the esophageal wall. Whether this gastric juice is a reflux into the esophagus from the stomach or whether it is produced in the esophagus itself because of heterotopic gastric mucosa is still controversial.[1]

The diagnosis of esophagitis should not be overlooked since the symptoms are so commonplace. Winkelstein,[2] in 1935, reported on a group of cases which he described as peptic esophagitis; Vinson and Butt,[3] Olsen,[4] and Allison,[5] have attested to its frequency. "Heartburn," a frequent complaint, is described by the patient as a burning sensation in the epigastrium or lower sternal region. Marked substernal pain referred to the throat, the neck, and the arms is seen in the more severe and far-advanced case. Moersch and Camp[6] are of the opinion that this type of pain is due to a diffuse esophageal spasm.

Many cases of mild esophagitis will subside and leave no sequelae, however, should the condition progress and become chronic, cicatrization of the lower part of the esophagus occurs. Olsen and Harrington[7] believe that such cicatrization may lead to actual shortening of the esophagus. It is questionable whether or not hiatal hernia should be considered a consequence of rather than the cause of esophagitis.

Of interest is the fact that these cases are frequently associated with gastroduodenal ulcers. Van Aken[8] reported three cases of stenosing peptic esophagitis, all of which had previous gastric resections for duodenal ulcers. He is of the opinion that the treatment of choice should be resection of the involved part of the esophagus.

Conservative treatment should be attempted in all cases of esophagitis prior to surgery. Such therapy consists of the neutralization of gastric secretions, elevating the patient's head, antispasmodics, and dietary regimes. If a cicatricial stricture occurs, dysphagia may be relieved by cautious dilatation in the hands of an expert, and should this fail resection may be indicated.

Wangensteen and Logan Leven[9] reported on six cases of esophagitis; they recommend subtotal gastrectomy as rational therapy to reduce the secreting surface of the stomach.

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Read at the Thirty-first Annual Meeting of the American Association for Thoracic Surgery, Atlantic City, N. J., April 16-18, 1951.

When the pathologic process has extended to such a point as to make resection impossible (chronic perforation with spillage, extensive fibrosis, and edema), the only recourse might be the establishment of an external esophageal fistula over a T-tube. After a perusal of the literature, no report could be found wherein a similar procedure was done for stenosing esophagitis.

Fig. 1.—A constant filling defect is noted at the lower end of the esophagus.

CASE REPORT

The patient, J. M., a 51-year-old man, entered the hospital complaining of dysphagia, and loss of weight of eight months' duration. His past history revealed numerous episodes of gastric distress for twelve years. Six years prior to entrance he was operated upon for a perforated peptic ulcer. With the exception of having been a heavy drinker, his past history was otherwise noncontributory. Dysphagia began to develop six months prior to entrance; this became worse progressively until he was able to swallow only small sips of water.

Physical examination revealed an emaciated man weighing 101 pounds, who appeared very ill but not in acute pain. The lower left chest was dull to percussion; diminished breath sounds were noted both anteriorly and posteriorly over the base of the left side of the chest. With the exception of an upper right rectus incision the findings were essentially normal.

Roentgenography showed a marked filling defect involving the lower third of the esophagus with almost total obstruction (Fig. 1). In the region of the lower left lobe of the lung an opacity about the size of an orange was noted. Atelectasis could not be ruled out.

Esophagoscopy revealed an almost total obstruction of the esophageal lumen 42 cm. from the gingival border. This appeared edematous, red, and bled easily. Biopsy of this section showed inflammatory tissue. Following esophagoscopy the patient ran a febrile course which was controlled within a week by conservative therapy.

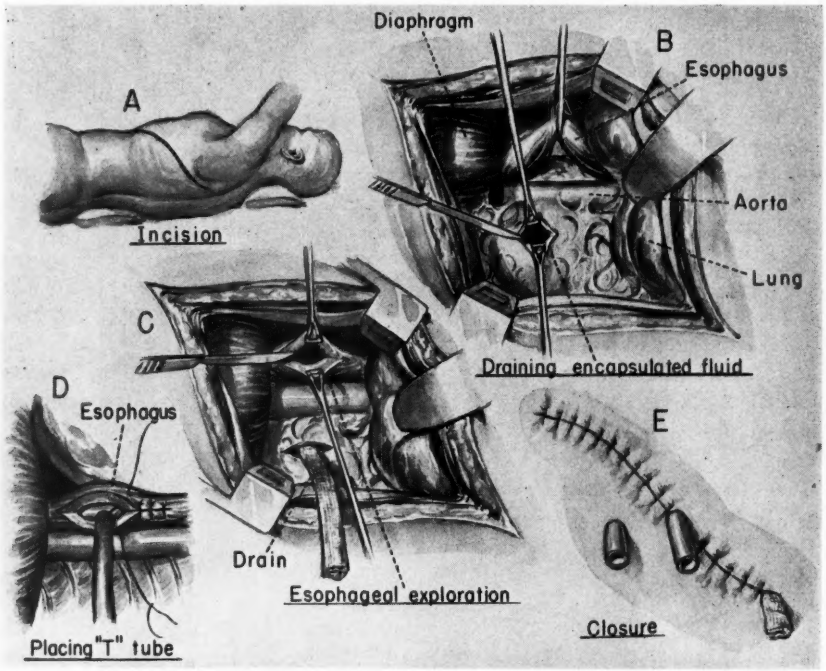

Fig. 2.—The operative procedure.

An exploratory thoracotomy was done ten days later, and an orange-sized mass in the left lower cavity was drained of turbid, flocculent, nonpurulent fluid (Fig. 2). The resulting cavity was emptied and packed completely, The lower lobe of the lung was firmly adherent to the left hemidiaphragm; the lower third of the esophagus was exposed and found to be scarred, rigid, and inelastic.

The involved portion of the esophagus was opened through a longitudinal incision to rule out a malignancy and to determine the size of the esophageal lumen. This disclosed a scarred and inflamed muscular layer and an almost obliterated lumen. No definite ulcer could be identified, although it was thought that at one time a small slow perforation occurred in this segment which leaked peripherally between the diaphragm and the lung, and accounted for the collection of turbid fluid found in the pleural cavity.

Resection was impossible because of the condition of the patient who was almost in extremis despite energetic and intensive preoperative care, contamination of the chest cavity, and the tremendous amount of fibrosis and edema which involved the lower end of the esopha-

gus. It was thought inadvisable to attempt to close the esophagus over an indwelling tube since an esophageal leak semed inevitable. The possibility of chronic perforation could not be ruled out.

A large semi-rigid T-tube was placed into the esophagus through the incision and an external esophageal fistula was created. The T-tube was sutured into place and bilateral vagotomy was performed. Although the T-tube was large, the dysphagia disappeared rapidly.

Fig. 3.—The T-tube shown in place in the lower end of the esophagus. It is noted that swallowed barium passes through the tube and around the tube, and readily fills the stomach. The limb of the tube which leads to the exterior is also filled with barium.

The patient was given fluids by mouth on the third postoperative day and a roentgenogram on the ninth postoperative day showed barium passing both into the stomach and out of the T-tube (Fig. 3). The T-tube remained in the esophagus for nine weeks, during which time the swallowed food which appeared externally out of the T-tube gradually diminished. Following removal of the T-tube the external opening closed within five days (Fig. 4), and the fistulous tract began to narrow and disappear.

Within the first six months of this procedure the patient gained 22 pounds, had a rather dilated esophageal lumen, no fistulous tract, and swallowed solid food with ease (Fig. 5).

This patient is being followed cautiously roentgenologically and will probably require an occasional dilatation; however, to date this has not been necessary.

SUMMARY

This report describes a case of stenosing esophagitis which resulted in almost complete obstruction of the lower end of the esophagus, and was associated with encapsulated fluid in the lower left chest, probably due to spillage from chronic perforation.

Fig. 4.

Fig. 5.

Fig. 4.—Five days following removal of the T-tube. Barium by mouth was given, and the narrowing of the fistulous tract is noted. The external opening of the tract is closed completely. The bulk of the barium has passed the now nonobstructed esophagus into the stomach.

Fig. 5.—Roentgenogram taken six months postoperatively. The barium passes freely into the stomach through a nonobstructed esophagus, and the fistulous tract has disappeared entirely.

Because of the patient's critical condition, practically in extremis, the contaminated pleural cavity, and the involvement of the esophageal wall, resection was considered impossible.

A T-tube was used to create a temporary external esophageal fistula.

To diminish hypersecretion and hyperacidity, bilateral vagotomy was performed.

At the present writing the patient feels perfectly well, his dysphagia has not recurred, and the fistula has closed.

After a perusal of the literature no report could be found of a procedure of this type being done for stenosing esophagitis with or without perforation.

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DISCUSSION

DR RICHARD H. SWEET, Boston.—It seems to me that this procedure is exceedingly unsound because, if some of our less experienced associates attempt to treat the esophagus in this manner, I have the feeling they will get into all sorts of difficulties that a less experienced operator might be expected to encounter. Dr. Thorek's moving picture shows, to my satisfaction at least, that the lesion he encountered would lend itself readily to resection. If the wall appeared to be involved in so much inflammatory thickening that it might not hold sutures satisfactorily, all that would be necessary would be to follow the esophagus upward to a proper level just below the aortic arch or above the arch, and then pull the stomach up and do an anastomosis.

I am quite certain that I have performed an esophagectomy in many cases in which there was esophagitis quite as bad as, if not worse than, in this case.

DR. THOREK (closing).—Just a word to thank Dr. Sweet for his remarks. I can state only that one must take sincerely the comments and criticisms of one so versed in esophageal surgery.

OBSERVATIONS AS TO THE ETIOLOGY AND TREATMENT OF ACHALASIA OF THE ESOPHAGUS*

EARLE B. KAY, M.D.
CLEVELAND, OHIO

THE physiopathology of achalasia of the esophagus is not clearly understood even though the first recorded case was in 1672[1] and theories as to etiology have been propounded in the literature ever since. This state of knowledge results from the differences of opinion regarding the anatomic and physiologic features of the esophagus and cardia of the stomach under both normal and diseased conditions.

The earlier investigators stressed the cardia of the stomach as the site responsible for this condition. In 1882, von Mikulicz[2] popularized the theory of a true spasm of a cardiac sphincter as being the etiology of a mega-esophagus. Einhorn,[3] in 1888, and later Hurst,[4] in 1914, propounded the theory of "failure of relaxation" of the cardiac sphincter, and termed this condition achalasia. Since this time observers have differed as to the presence of a cardiac sphincter.

At the present it is generally accepted that a cardiac sphincter as such does not exist but that there is a closing mechanism present at the cardia produced by the slinglike action of the inner and oblique muscle layers of the stomach partially encircling the cardia. Experimental observations suggest that this mechanism, in conjunction with the septum between the esophagus and cardia on the left side, is probably more important in preventing regurgitation than it is in participating in the act of deglutition. Both experimental and postmortem observations show that the cardia appears to be in a state of relaxation except when the stomach is distended. Inspection of the cardia during the performance of a cardioplasty as well as microscopic examination of sections taken from the cardia of patients with achalasia elicit no abnormal findings. The junction between the esophagus and cardia also appears normal. There is, however, generalized hypertrophy of the esophageal musculature and particularly the circular muscle of the terminal esophagus, as will be described later.

Extra esophageal lesions such as deformity of the "liver tunnel" with kinking of the esophagus,[5] periesophageal fibrosis,[6] incoordination of the diaphragmatic crura,[7] phrenospasm,[8] and failure of the diaphragmatic pinchcock to open during the process of deglutition[8] have all been proposed as causing the obstruction. None of these theories have been substantiated.

Next, various neurogenic theories were presented. These were based on microscopic and experimental observations. Rake[9] (1927) described absence of and degenerative changes in the cells of Auerbach's plexus in the lower

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esophagus in patients having achalasia. This finding deserves more emphasis than generally accorded it. As illustrated in Fig. 1, Auerbach's plexus, as well as the myenteric nerve fibers, may appear essentially normal. In other cases the ganglia cells may be difficult or impossible to find, or may show round cell infiltration, fibrosis, and degeneration. The scarcity of ganglion cells might be interpreted as being the result of the esophageal dilatation and not the result of the loss of ganglia if it were not for the fact that the contracted terminal segment of the esophagus appears to be more lacking in ganglion cells than in the dilated portions. There appears to be a correlation between the scarcity of ganglion cells and the degree of achalasia. The photomicro-

Fig. 1.—Photomicrograph of Auerbach's plexus showing some degeneration of the ganglion cells in a patient with moderate degree of achalasia (Fig. 2). (×120.)

graph illustrated in Fig. 1 demonstrates the presence of ganglia cells showing some granulation suggestive of degeneration in a patient with a moderate degree of achalasia as demonstrated by the esophagram in Fig. 2, as compared to the photomicrograph in Fig. 3 where multiple serial sections failed to show any ganglia cells even though there were numerous nerve bundles. This patient had the most severe type of achalasia seen. The entire right hemithorax was filled with this dilated esophagus, as demonstrated in Fig. 4.

The peristaltic reflex and muscular action of the distal esophageal segment are under the control of the ganglion cells. When there is degeneration, reduction, or absence of these ganglion cells, or when the myenteric plexus is

destroyed experimentally as demonstrated by Tamiya and Tamura[10] there is a preponderance of sympathetic control; muscular coordination is impossible; and the circular fibers become contracted and hypertrophied to the degree of causing esophageal obstruction. As the result of this obstruction secondary esophageal dilatation and hypertrophy develop above. When the pressure within the esophagus builds up, or if the patient voluntarily increases his intrathoracic pressure by the Valsalva maneuver food or barium can be pushed into the stomach. Barium may also be demonstrated fluoroscopically to enter the stomach during the midrespiratory phase, as will be described later. The foregoing findings are similar to those observed in megacolon.[11, 12] The parallelism between these two conditions is of interest.

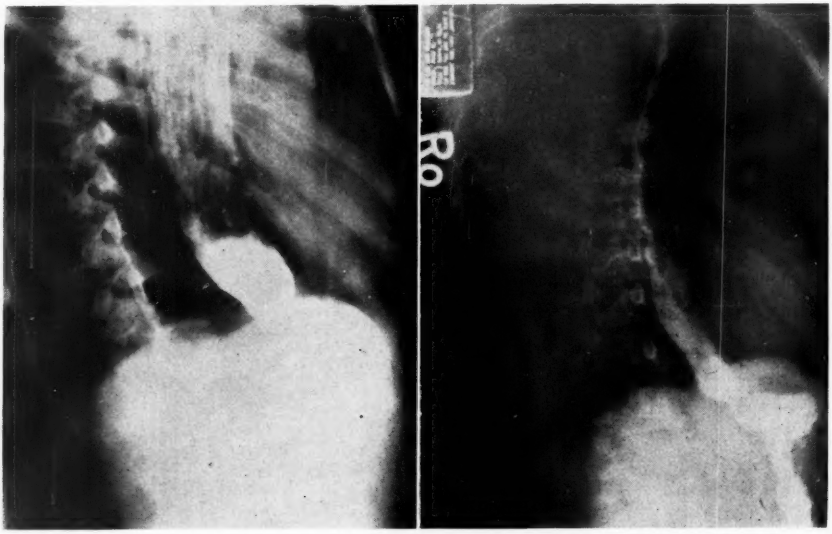


Fig. 2.—Esophagus demonstrating achalasia of esophagus before and after Heineke-Mikulicz type of cardioplasty.

When the obstruction is relieved by dilatation or operation, peristalsis may be restored and the esophagus may reduce in size if the degree of dilatation has not been too extensive, which suggests that the ganglia and nerve fibers of the upper esophagus are capable of function. If this condition were due to vagal nerve damage one would not expect peristalsis to be re-established. A stage in the diseased process may be reached, however, where irreversible damage to the esophageal wall and nerves may have occurred. The pathologic findings presented consequently are dependent upon the stage of development of the achalasia. The more extensive findings are usually found in the greately dilated sigmoid type of esophagus.

Knight[13] and Knight and Adamson[14] presented experimental evidence to show that the condition can be simulated experimentally in cats by sectioning the vagus nerves. They also showed that this experimentally produced

mega-esophagus can be prevented by simultaneous section of the sympathetic fibers, or when produced can be relieved later by this procedure. This led to the view that inherent disease in the vagus nerves might be responsible.

Stimulation of the vagus nerves at the time of operation causes contraction of the esophageal musculature and relaxation of the sphincter in the milder cases of achalasia. No significant muscular response is seen following vagal stimulation in the far-advanced case, which suggests that the vagal dysfunction may be a secondary manifestation in the far-advanced case, or, of course, may be without effect because of possible loss of underlying ganglion control. This finding is in keeping with fluoroscopic evidence of increased primary and secondary peristalsis in the upper and mid-esophagus in patients

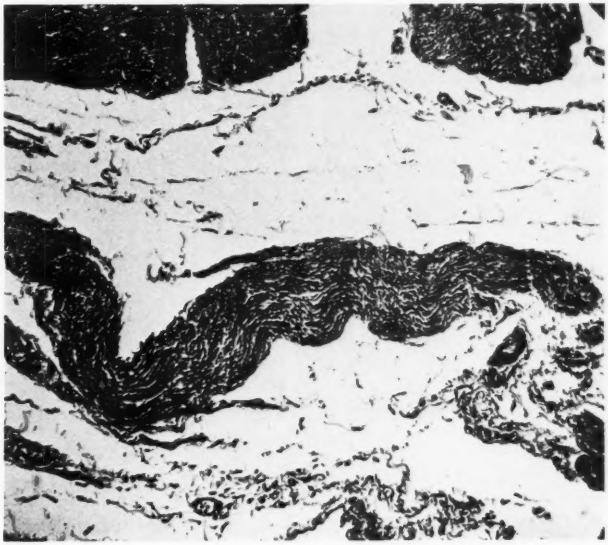


Fig. 3.—Photomicrograph of Auerbach's plexus demonstrating absence of ganglion cells in severe type of achalasia as demonstrated in Fig. 4. (×120.)

with milder degrees of achalasia, as compared to the complete loss of peristalsis and loss of esophageal tone in the far-advanced stage. A condition simulating achalasia may result from a chronic mediastinitis or mediastinal lymphadenopathy with involvement of the vagus nerves.

Vagal denervation associated with esophageal mobilization causes dilatation of the esophagus and contraction at its terminal region. Also transthoracic vagotomy for peptic ulceration is occasionally followed by transitory terminal esophageal spasm which persists for three to five weeks before the esophagus recovers its own automaticity.

The terminal esophagus in some patients with achalasia can be demonstrated fluoroscopically to dilate like a sphincter under the influence of amyl nitrite and ergotamine (Fig. 5). No such action is noted in other regions of

the esophagus. This sphincterlike mechanism can be demonstrated by surgical dissection to be hypertrophied circular muscle fibers confined to the distal 2 or 3 cm. of the terminal esophagus; above this site the circular and oblique fibers are not hypertrophied to the same extent. The dilating action of amyl nitrite on the sphincterlike mechanism of the hypertrophied circular muscle in the terminal esophagus has also been observed in some cases of achalasia at the time of operative exposure.

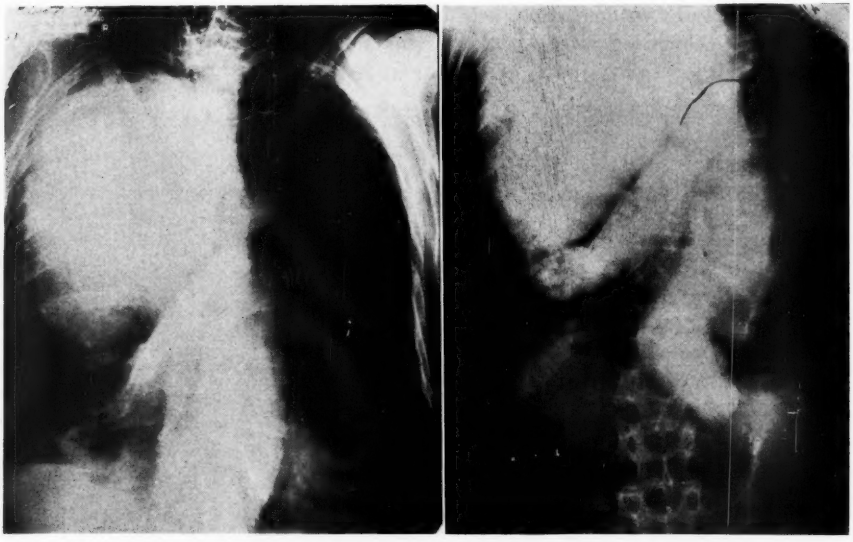


Fig. 4.—Esophagram demonstrating markedly dilated esophagus filling entire right hemithorax.

Why the circular muscle layer in the distal esophagus should hypertrophy to the extent of causing functional esophageal obstruction with secondary esophageal dilatation above and not respond in the normal manner to either the primary or secondary esophageal peristaltic waves is not known, but appears to be the result of lack of ganglion control and coordination. Etzel[15] has suggested a vitamin B deficiency as a possible cause of the nerve damage when degeneration of the ganglion cells is seen. In support of this theory are other types of so-called "functional dysphagia" which respond to vitamin B therapy. The reduction in number or complete absence of ganglia cells in the terminal esophagus may be on a congenital or developmental basis. Others[16] have suggested psychogenic causes. Those emotional problems seen in these patients are more likely due to their esophageal dysfunction than to primary psychic disorders, for they soon disappear when normal eating is restored. One might say, however, that the majority of these patients tend to be the apprehensive introspective type of individual.

It is felt that a review of certain of the anatomic features of the esophagus and cardia would be pertinent to this discussion. The esophagus has a well-

developed outer longitudinal muscle layer and a less well-developed inner muscle. The longitudinal muscle extends from the cricoid cartilage and cricopharyngeus muscle above to insert below in an interlacing manner into the middle and outer muscle layers of the cardia. Muscle fibers from the aorta, bronchi, and pleura attach themselves to the longitudinal muscle throughout its course. The upper one-fifth is striated, and the remainder is smooth muscle.

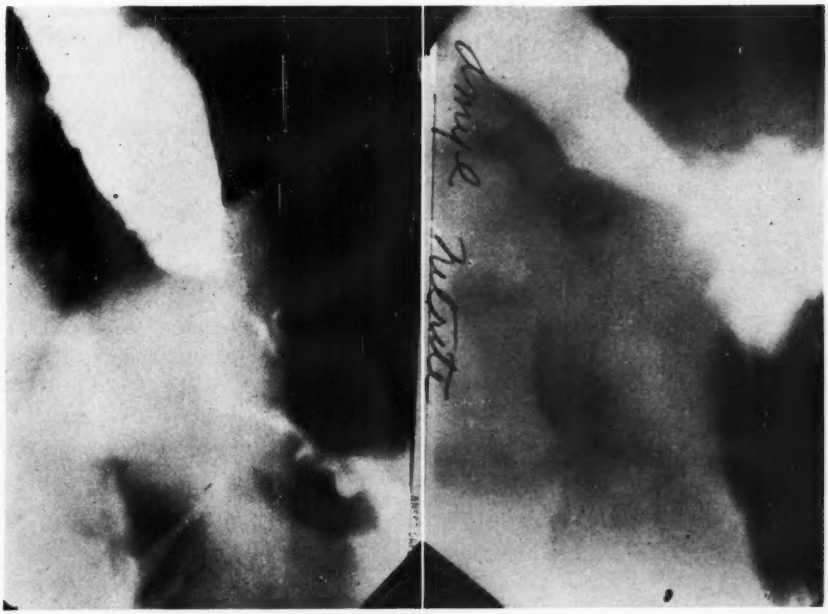


Fig. 5.—Roentgen evidence of dilating effect of amyl nitrite on circular muscles of terminal esophagus in patient with achalasia.

According to Lerche,[17] Laimer described the inner muscle layer of the esophagus as commencing in the upper end independently of any other group of muscle fibers. The arrangement of these fibers varies in the different segments of the esophagus. These muscle fibers run in an elliptical direction around both sides of the esophagus and downward in the upper third of the esophagus. A small segment of the mid-esophagus about 1 cm. in length has circular fibers, below which they again run in an elliptical course in a downward direction toward the posterior aspect of the esophagus. In the lower esophageal third, according to these authors, the muscle fibers wind about the esophagus in a spiral manner. There are also occasional spiral fibers throughout the other segments. These spiral fibers appear to be responsible for the tertiary contractions and "curling" occasionally noted fluoroscopically. The inner muscle layer of the esophagus continues in the inner and middle muscle layers of the cardia and stomach. Less often there are elliptical or circular

fibers in the esophagus just above the cardia. Laimer and Lerche also described from anatomic studies a circumscribed thickening of the inner muscle layer approximately 1 to 3 cm. above the diaphragmatic hiatus which they referred to as the lower physiological constriction or the inferior esophageal sphincter. Deeper longitudinal fibers from this sphincter insert into the longitudinal layer and have a dilating action on the sphincter.

According to the above description these separate muscle fasciculi appear quite apparent but unless they are carefully searched for the variations of the inner muscle layer and particularly the sphincterlike action of the circular and elliptical fibers in the terminal portion of the esophagus may not be too obvious.

As contrasted to the normal, anatomic and surgical dissections reveal the inferior esophageal constriction in patients having achalasia to be very definite and composed of markedly hypertrophied circular and elliptical muscle fibers extending from the esophagogastric junction upward for 2 to 5 centimeters. This area corresponds to the contracted distal segment of the affected esophagus.

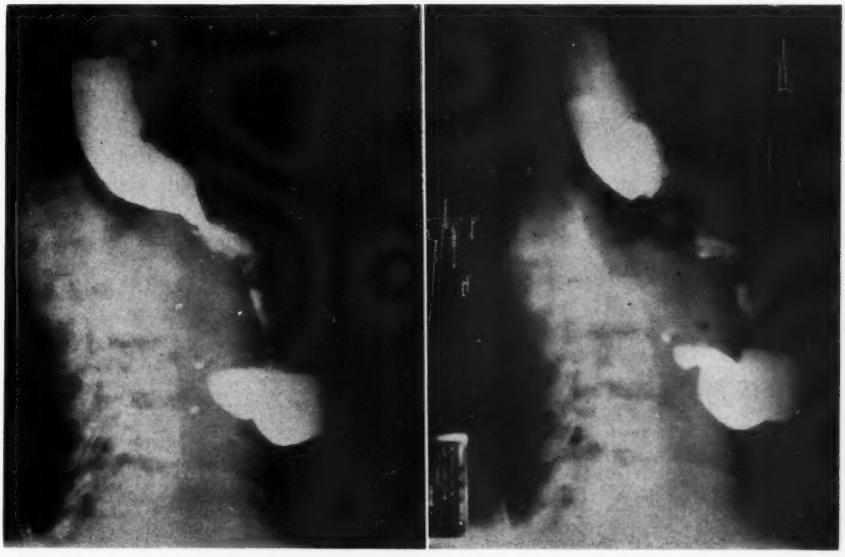
The diaphragmatico-esophageal ligament may also play a role in both normal and abnormal deglutition. This ligament was first described by Laimer[18] in 1883. It arises from the fascia on the under surface of the diaphragm. At the hiatus it divides into an ascending part that extends upward and attaches to the longitudinal and circular muscle fibers of the lower esophagus at the site of the inferior esophageal constriction or sphincter, and a descending limb that attaches to the cardia. This ligament is the antagonist of the longitudinal muscle of the esophagus and prevents the esophagus from pulling the stomach into the chest during swallowing. There is considerable variation in the thickness of this ligament. When it is stretched or atrophic it may be one of the factors responsible for the development of hiatal hernias. In some patients with achalasia the ascending limb of this ligament has been taut and hypertrophied, and has appeared to be playing a role in the causation of the esophageal constriction. In one patient, not until this ligament was entirely sectioned at a secondary operation was the esophageal obstruction relieved.

It can be demonstrated fluoroscopically that the point of obstruction in patients with achalasia is definitely related to the stress upon either the ascending or descending limb of this ligament. As illustrated in Fig. 6 on deep inspiration the diaphragm descends, the ascending limb becomes taut and the point of esophageal obstruction is several centimeters above the diaphragm. On expiration the diaphragm ascends, the descending limb becomes taut, and the point of obstruction is then at the cardial junction.

The diversity of opinion regarding the etiology of cardiospasm has also been reflected in the multiplicity of measures employed for its relief. Ochsner and DeBakey[19] have ably covered the literature on this subject and the reader is referred to this review. Only those therapeutic measures designed to enlarge the inferior esophageal segment and cardia have survived the test of

time. Other measures attacking the esophagus proper, the diaphragm, or the nerve control have failed in their expectations. The techniques most commonly employed have little specificity as to the exact site of benefit and are of little value in contributing knowledge as to either this site or to the nature of the obstruction.

Patients with mild to moderate degrees of achalasia frequently obtain considerable relief of symptoms and occasional reduction in the size of the esophagus following mechanical dilatation. This dilating effect, however, is employed throughout the terminal esophagus and cardia so it is impossible to say with certainty exactly what had to be dilated.



A. *B.*

Fig. 6.—Esophagrams demonstrating that point of esophageal obstruction related to the stress upon either the descending or ascending limb of the diaphragmaticoesophageal ligament. *A*, expiration; *B*, inspiration.

In other patients with more severe degrees of achalasia dilatation may not be possible because of the tortuosity of the esophagus or the benefit is so temporary as to be without value. These patients can be benefited by operative procedures. These procedures fall largely into two classes, the cardioplasty of either the Finney or Heineke-Mikulicz type performed either from above or below the diaphragm and the cardiomyotomy somewhat modified from that originally described by Heller.

The majority of those surgeons employing the Finney type of cardioplasty have stated that there is more symptomatic improvement than there is objective evidence of relief of the obstruction. The Heineke-Mikulicz procedure performed transthoracically as described in a previous communication[20] not only gives symptomatic relief but objective evidence of marked

reduction in the size of the dilated esophagus. In many patients return of peristalsis and muscular tonicity is evident following relief of the obstruction. Again as in esophageal dilatation, these surgical procedures are not specific as to their site of benefit. These techniques necessitate an incision through the lower esophagus, esophagogastric junction, and cardia so that all structures are incised. These operations are usually followed by both functional benefit and also evidence of reduction in the size of the esophagus if the new stoma is made sufficiently large.

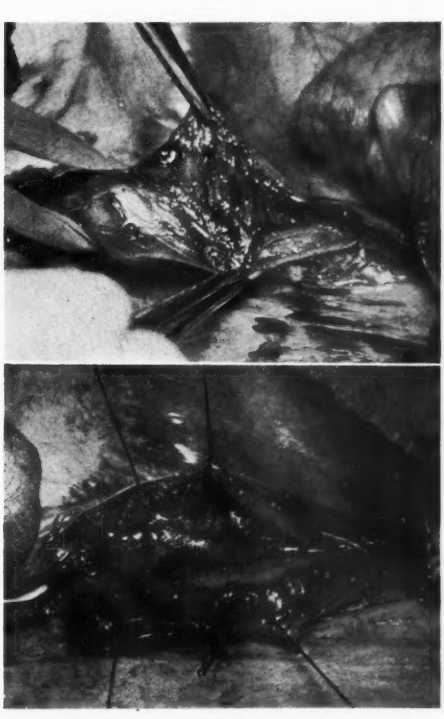
Though relief of esophageal obstruction is obtained and the patient is satisfied with his ability to swallow, the incidence of regurgitation esophagitis and gastritis with secondary bleeding and anemia is so high as to make this operative technique less attractive. Nine of thirty-two (28 per cent) patients having a Heineke-Mikulicz or Finney type of cardioplasty have had evidence of esophageal bleeding and anemia. In four of the patients bleeding was severe. All of the nine patients have to follow a carefully regulated ulcer regimen. Gastric analysis has not shown hyperchlorhydria. Two of the patients who have bled most severely showed a persistent achlorhydria. In one of these patients it was necessary to do a secondary gastric resection to control the ulceration and bleeding. This particular patient originally had a Finney type of cardioplasty performed transabdominally. Vagus section at the time of the cardioplasty appears to be of no value in the prevention of this ulceration and bleeding and may give further symptoms secondary to possible pylorospasm.

Because of this incidence of bleeding associated with the cardioplasty technique, it was felt that a better long-range result might be obtained following resection of the lower esophagus along with the cardia and fundus of the stomach. Of three patients so treated and followed for two years, all three have been able to eat satisfactorily, but one follows quite closely an ulcer regimen because of the occurrence of a regurgitation esophagitis and hemorrhage one month postoperatively. There has been no evident subsequent bleeding.

Though this technique appears to be satisfactory, the results are no more gratifying than what can be obtained by a modified Heller operation which is of considerably less operative magnitude. During the past year six patients ranging from 9 to 53 years of age have been operated upon by the modified Heller technique. There has been a satisfactory functional response in all, with a corresponding gain in weight. There has been no evidence of postoperative esophagitis and bleeding in these patients as yet. It is felt that by preservation of the esophagogastric junction in the technique to be described accounts for the absence of regurgitation and prevents the development of an esophagitis.

It is of interest that in the careful performance of the modified Heller technique, a markedly hypertrophied circular muscle at the site of the inferior esophageal sphincter described by Laimer and Lerche has appeared sufficiently contracted as to be responsible for the esophageal obstruction.

The Heller operation as originally performed consisted of exposure of the stomach and cardia through a laparotomy incision, mobilization of the terminal esophagus and cardia and parallel longitudinal incisions of the musculature down to the mucosa anteriorly and posteriorly.



A.

B.

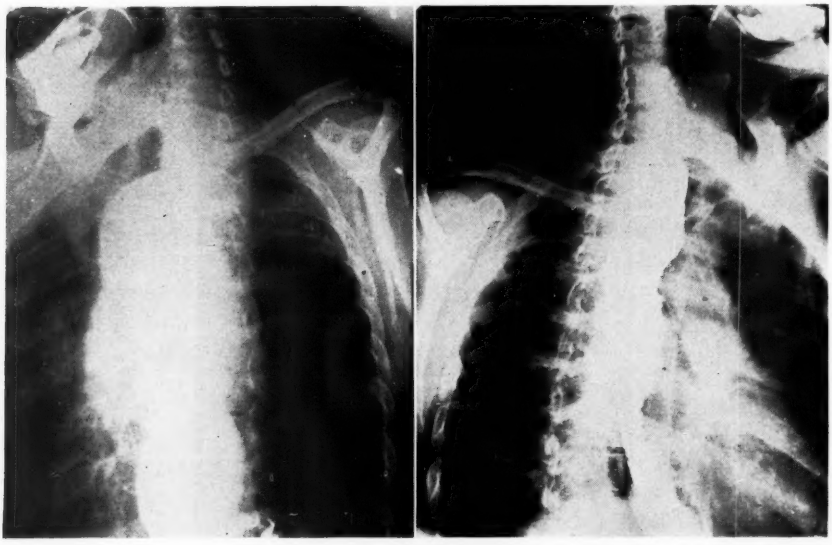
Fig. 7.—Surgical exposure demonstrating hypertrophied circular muscle fibers in terminal esophageal segment before *A*, and after *B*, severing these fibers and allowing the mucous membrane to bulge.

The technique as now performed in these patients through a thoracotomy incision consists of separating the longitudinal muscle of the terminal esophagus and isolating the hypertrophied circular muscle. This has been approximately two times the thickness of the longitudinal muscle. This hypertrophied circular muscle which extends upward from the esophagogastric junction for 1 to 5 cm. is then severed allowing the submucosa to bulge (Fig. 7). Heretofore the esophageal musculature has been divided down to the submucosa without differentiation into two layers.

The results of transecting this sphincterlike hypertrophied circular muscle has been gratifying in all patients so treated even though there has not been

as complete a reduction in the size of the esophagus as usually noted following a Heineke-Mikulicz cardioplasty (Fig. 8).

As experience is gained in the treatment of this condition it may be found that the type of operative procedure employed in those patients not responding to dilatation will depend largely on the pathologic features of the presenting esophagus. In extensively dilated esophagi with loss of peristalsis the most satisfactory procedure may still be a cardioplasty or a partial esophagogastric resection where a large stoma can be made which cannot possibly allow a retention of food. In the less extensive cases the modified Heller operation will suffice. From experience so far attained it appears that this



A. *B.*

Fig. 8.—Esophagrams demonstrating achalasia of esophagus before and after modified Heller cardiomyotomy.

latter operation, however, when correctly executed, will fulfill all of the surgical requirements and not be associated with unfortunate postoperative complications such as regurgitant esophagitis.

In conclusion, there is evidence to show that when there is degeneration, reduction, or absence of ganglion cells in Auerbach's plexus, a preponderance of sympathetic control develops; muscular coordination is impossible; and the circular fibers become contracted and hypertrophied to the degree of causing esophageal obstruction with secondary esophageal dilatation and hypertrophy above. This terminal esophageal obstruction can be adequately relieved by dilatation or by severing the hypertrophied circular muscle in the terminal esophageal constriction or sphincter.

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DISCUSSION OF "THE TREATMENT OF CARDIOSPASM: ANALYSIS OF A TWELVE-YEAR EXPERIENCE," BY DR. ARTHUR M. OLSEN, DR. STUART W. HARRINGTON, DR. HERMAN J. MOERSCH, AND DR. HOWARD A. ANDERSEN, AND "OBSERVATIONS AS TO THE ETIOLOGY AND TREATMENT OF ACHALASIA OF THE ESOPHAGUS," BY DR. EARLE B. KAY

DR. OWEN H. WANGENSTEEN, Minneapolis, Minn.—I had the opportunity to discuss the subject of mega-esophagus at the recent meeting of the American Surgical Association in Washington. However, because of the more complex nature of this audience I welcome the opportunity to say something about it here. In his splendid presentation of his subject, my colleague from Rochester, Minnesota, Dr. Olsen stated that 25 per cent of his patients were untraced. It is probably well to remind ourselves that, it is easier to trace the satisfied patient than the dissatisfied patient.

Mikulicz gave this entity its name, in 1882, when he called it cardiospasm. I believe some light is coming into our understanding of the nature of the disturbance. I prefer to call this entity dystonia rather than cardiospasm or achalasia, because the disorder has two components, namely; hypertonus of the distal segment and atony of the more proximal unstriated musculature of the esophagus.

The objective of conservative management is a bloodless myotomy of the hypertonic segment. In Dr. Olsen's traced cases that objective apparently was achieved in 60 per cent

of instances in one hydrostatic dilation. My plea would be for earlier resort to operative myotomy if one or two attempts at bloodless myotomy fails. In many of our Outpatient Clinics, patients are coming back repeatedly over a period of years for dilatation. In other words, some of these patients are denied effective treatment and are subjected to periodic dilatations of the hypertonic esophageal segment with bougies. Cures of esophageal dystonia by dilatation with bougies must be infrequent. Distrust of, or dissatisfaction with conventional surgical treatment of the management of mega-esophagus is probably, in part, responsible for this practice. Now, that the desiderata of satisfactory surgical management of esophageal dystonia, are becoming evident, there is no need to temporize indefinitely with bougie and hydrostatic attempts at esophageal dilatation. Moreover, as Dr. Olsen has indicated, hydrostatic dilatations also carries hazard.

The honeymoon of many an operative procedure for esophageal dystonia is over, and the last of some of the proopsed operations, let us hope, has been done. I speak especially of the Wendel and the Heyrovsky-Gröndahl operations for cardiospasm. Both these operations, it is now known, invite esophagitis. The two operations which correct the condition without being followed by esophagitis are the Heller extra-mucosal myotomy and the operation described by me in 1949, in which the tortuous distal end of the esophagus is excised together with the entire acid secreting area of the stomach. That there should be such an important difference between the results of the Wendel procedure of open cardioplasty and the Heller extra-mucosal myotomy is very interesting. It had been believed, of course, that the only important condition to be met was to provide satisfactory emptying of the dilated esophagus. It now turns out that the Wendel procedure encourages regurgitation of acid-peptic juice into the esophagus, whereas the Heller operation apparently does not. Barrett of London has presented critical evidence on this point. (Proceedings of the Royal Society of Medicine, June, 1950, Section on Surgery.)

It is for the tortuous, baglike esophagus that I have done the larger operative procedure, straightening out the esophagus and excising its tortuous distal segment, together with the hypertonic segment and the entire acid secreting area of the stomach. A coincidental Ramstedt procedure is also done on the pylorus to insure satisfactory gastric emptying after excision of the vagi nerves, which of necessity attends the procedure.

Demonstration of the sensitivity of the esophagus to acid-peptic juice was, I think, a startling observation to all of us. Most of us had been unaware of it. It had been reported now and then. The paper by Pringle and Teacher of Glasgow (1919) is particularly good. Yet, pathologists had continued to insist that the evidences of esophagitis, and even perforation of the esophagus occasionally observed at post mortem—that these were essentially agonal or post mortem changes owing to softening of the esophageal wall occasioned by the reflux of acid-peptic juice into the esophagus during the agonal state. We need to remind ourselves periodically that there are no Delphic oracles in medicine. Observations in the experimental laboratory have shown that the esophagus is more sensitive to acid-peptic juice than is any juxta-gastric lying mucosa. The cat's esophagus may perforate within twenty minutes, attending the dripping of gastric juice into it, obtained from an isolated canine gastric pouch; the cat's esophagus is by no means that sensitive to injury by hydrochloric acid of the same pH.

In doing the Heller myotomy, I like to make a short transverse gastrotomy incision in the upper stomach. Under visual and tactile control, with the finger inserted into the esophagus, the division of the muscular fibers of the hypertonic segment is readily done, without risk of injury to the mucosa. Moreover, this incision should be adequately long. Ten to twelve centimeters is not too long. Some of the reported failures, in the Heller myotomy, are undoubtedly owing to the myotomy being inadequate. I like to assess whether or not the deepest fibers of the circular muscle have been divided by the aid of a large magnifying glass. The median extrapleural sternotomy incision gives direct and easy access for performance of either the Heller myotomy or the more formidable procedure of excision of the acid secreting area of the stomach, together with the tortuous lower segment of the esophagus.

I believe there is a functional sphincter at the esophagogastric juncture. It never acquires the proportions of a tumor as in hypertrophic pyloric stenosis; I do not believe the sphincteric action is owing to any diaphragmatic attachment. When one inserts his finger at operation through the esophagogastric juncture he can feel the constriction, just as when the finger is inserted through the pylorus. Maybe, some day, the anatomists will recognize the presence of a sphincter at the gastric inlet.

In the discussion of this subject at the recent meeting of the American Surgical Association, Dr. Evarts Graham stated that he had been performing myotomy operations on the rectosigmoidal area for megacolon. I am inclined to believe that mega-esophagus, congenital hypertrophic pyloric stenosis, and megacolon may be somewhat related entities.

Finally, I want to say that I do not believe that diffuse esophageal spasm is mega-esophagus at all; the spastic proximal reaches of the esophagus are hypertonic and not atonic as in the usual esophageal ectasia. If a patient has had dysphagia for several years and there is no atony or ectasis, the patient does not have so-called cardiospasm or mega-esophagus. Understanding is beginning to come into the realm of the misunderstood esophageal dysphagias. Idiopathic stricture and spontaneous perforation of the esophagus are manifestations of acid-peptic disease, owing to reflux of gastric juice. Mega-esophagus is a functional disorder, probably owing to absence in the esophageal wall of nerve cells in the terminal plexuses of the parasympathetic nervous system. Neither sympathectomy nor vagotomy have any place in the treatment of mega-esophagus. When an attempt or two at effecting a bloodless myotomy by hydrostatic dilatation fails, operation is in order. And satisfactory operations are now available with which to treat the disorder, as well as to thwart the complication of esophagitis which has been the nemesis of many operative procedures suggested for the relief of esophageal dystonia.

DR. RICHARD H. Sweet, Boston, Mass.: I must say that I have enjoyed these two presentations and the discussion very much. The sum total of it all is that I am in a far greater state of confusion now than I was when I came here; I might add that that is considerable.

In the first place, I have a very definite belief that it would be advantageous to us to abandon the term "cardiospasm." I personally have not observed cardiospasm in any of these cases, although perhaps the trouble is that I am not seeing the same type of patient. I do not find that the difficulty, the objective finding, at any rate, is at the cardia at all. This has been very striking to me. To be sure, my own experience is limited, having operated on only thirty-two cases, but I have observed that the abnormal region is not at the cardia but just proximal to it. This observation holds for all the cases I have actually exposed surgically through the thorax with good exposure and visualization of the lower end of the esophagus. It is very striking that the lower end, sometimes for a distance of several centimeters, sometimes only one or two, is strikingly narrow; it is hardly the size of an infant's esophagus at that point; its wall is thin. I cannot find that sphincter that Dr. Wangensteen speaks about although I have looked for it, and I cannot find the hypertrophy of that region that Dr. Kay described. It always looks to me like a small atrophic segment and yet proximal to that we see the enormous dilated hypertrophied boggy tortuous esophagus.

With regard to the Auerbach's plexus, in the six patients on whom I have carried out a resection, and two others in whom a secondary resection was done, making eight in all, we have searched for evidences of the ganglion cells and have found them diminished or absent, not only in the small atrophic-looking distal segment, but also as far up on the esophagus as we have gone. This finding has been pointed out before by others. Our experience with dilatation has been similar to that of this marvelous series of Dr. Olsen. From the standpoint of surgical treatment, I thought I might rehearse for you my experience with thirty-two cases. There were six primary resections. All had 100 per cent relief of dysphagia. But I find on review of the cases that there were two with signs or symptoms of esophagitis; one had some hemorrhage. Of the twenty-six on whom I performed esophagoplasty, by the method of longitudinal incision and circumferential closure, which I think must be rather an extensive one as Dr. Wangensteen pointed out, four showed some signs or symptoms of esophagi-

tis; one of those had slight hemorrhage, and two had massive hemorrhage requiring reoperation and radical resection. So we have seen three cases of hemorrhage in the twenty-six patients.

I am not yet prepared to give this procedure up. I think if we surgeons had given up subtotal gastrectomy for duodenal ulcer in the early days of its use we would have come to regret it. There are certain other operations also which have gone through a phase of experimental development. I feel, therefore, that in the limited number of cases of mega-esophagus, idiopathic dilatation, or whatever we chose to call it, where surgery may be required, that it is up to some of us to try to improve the technique. I think that one error I have made in the past has been to allow the stomach to rise above the diaphragm. I think we shoudl maintain the integrity of the diaphragm and keep the stomach down, because some of our cases have had gastritis as well as esophagitis. It seems to me, in conclusion, that the problem is not quite as easily solved as it would seem to be on superficial thought.

DR. JOHN H. GARLOCK, New York.—We, too, have had our troubles with this condition, and I would like to report our experience with twenty-one patients who were operated upon. Our gastroenterologists have referred for surgery only those patients who had a mego-esophagus with reduplication of the organ rather than the straight conical variety without elongation of the organ. Our experience, therefore, has been limited almost entirely to the complicated variety.

(Slide) As you will see, we have operated on twenty-one patients and have confined the operative procedure to two varieties; the Heyrovsky-Finney or Gröndahl operation was done on ten patients and the transthoracic lateral anastomosis was done on eleven patients. The results are indicated. There were two cases of bleeding in the first group and one in the second group secondary to a peptic esophagitis. It has been our experience that the longer these patients are followed, the greater will be the incidence of esophagitis and subsequent hemorrhage, and that has been the difficult problem so far as we are concerned. There is very little disturbance in the act of deglutition after an adequate anastomosis has been made, but the regurgitation of acid juices from the stomach, or whatever other factor causes that particular circumstance, the subsequent development of esophagitis and bleeding in an increasing number of cases is the important item in appraising the results of the various operations.

I do not think that the problem is as simple as Dr. Wangensteen has indicated in his discussion. This opinion is based on our experience with a number of patients in whom the physiologic gastric studies were so bizarre as to make one wonder about the role of regurgitated gastric contents in the subsequent development of esophagitis. I would like to cite briefly two such cases. There was one patient who had in 1948 in another hospital a Heineke-Mikulicz cardioplasty by a combined abdominothoracic incision. He developed marked esophagitis and hemorrhages. He was operated upon again because the roentgenogram suggested strongly the presence of a duodenal ulcer. The esophagoscopy at that time was negative. He had a high subtotal resection for a scarred area in the first portion of the duodenum which was thought to be a healed ulcer. The severe hemorrhages continued. Esophagoscopy then revealed that he had an extensive peptic esophagitis with ulceration. In 1949, a jejunostomy was done to put the esophagus at rest, and six months later a transthoracic lateral esophagogastrostomy was done. Since that time he has been perfectly well and, in spite of the fact that he had a lateral anastomosis with every reason for regurgitation of gastric juice, he has had complete healing of the esophagus.

The second case I think is more important. This was a woman 42 years of age with a long-standing history of dysphagia due to cardiospasm. She had a transthoracic lateral anastomosis done in 1949. She developed bleeding, due apparently to peptic esophagitis. Yet, on complete workup, she has a complete achlorhydria. The problem, I think, will have to be solved by methods other than those utilized at present, and I would like to call attention to the very stimulating article in a recent issue of *Surgery, Gynecology and Obstetrics* by Allison, of Leeds, England, in which there is described a new approach to the anatomy and physiology of the cardia and the esophageal diaphragmatic opening. I think possibly the answer will be a local resection with an anastomosis, or a lateral anastomosis, with reimplanta-

tion of the cardiophrenic ligaments so as to restore the pinchcock action of the two crura which was so well brought out by Mr. Allison in his article.

It is a curious observation that, in doing resections of the esophagus for carcinoma, one is never bothered by esophagitis or hemorrhage at a later date. Perhaps the vagal resection done at operation is a factor and perhaps in the operation for cardiospasm, vagotomy should be an added maneuver.

DR. E. K. JOHNSON, Brooklyn, N. Y.—We have seen a few children or infants with achalasia, or narrowing of the esophagus, at the pharyngo-esophageal junction. Perhaps the most interesting case was a young girl of 12 years, who was seen because of difficulty in swallowing. A tonsillectomy had been performed when she was 3 years old, after which she refused to take anything but liquids.

(Slide) This shows the pharynx outlined by barium which failed to enter the esophagus. She refused to take any more.

(Slide) The lateral view, at the pharyngo-esophageal junction, shows the narrowing.

(Slide) The postoperative esophagram reveals good filling. Using a cervical approach, the narrowed part of the esophagus was located. We found a thickened muscular band which had completely constricted the esophagus. Using a modified Heller procedure, the band was divided on the left side and a large catheter was passed without difficulty by the anesthetist.

(Slide) The diagram shows the site of the constricting band.

(Slide) We thought the band might be fibrous, but it was entirely muscular.

Her postoperative course has been very smooth and she eats her meals in normal fashion and has gained considerable weight. I thought this case was so similar to congenital hypertrophic pyloric stenosis and cardiospasm that it may prove of some interest here.

DR. M. E. DE BAKEY, Houston, Texas.—About ten or eleven years ago Dr. Ochsner and I reviewed this subject with particular reference to its surgical considerations. Among the various terms employed for the disease we preferred the term achalasia because we were inclined toward the pathogenic concept implied by it. It was pointed out at that time that the multifarious designations for the disease, as well as the various types of therapeutic procedures advocated for its treatment, reflected the state of confusion in our understanding of the disease. After listening to the discussions today I feel like Dr. Sweet, that this state of confusion has not been materially changed.

Critical evaluation of results of any operation proposed for this condition is highly important. At the time of our review and evaluation of the various procedures proposed, which are virtually the same as those presented today with the exception of the more radical procedure suggested by Dr. Wangensteen, we were impressed with the fact that most of them were enthusiastically reported to provide excellent results. This is particularly true for the so-called Heller operation which has again been enthusiastically advocated today. The fact that this operation was proposed by Gottstein approximately fifty years ago, first performed by Heller almost forty years ago, subsequently modified by a number of other surgeons, and abandoned and revived from time to time, strikes me as significant. Such considerations in the historical development of an operative procedure usually reflect dissatisfaction with its ultimate results as well as with its rationale. For these reasons it would seem desirable in the current revival of this operative procedure to provide additional facts for its rationale. The question which needs to be answered is why is it a better operation now?

The etiology of the disease remains unknown and, so far as I know, during the past decade little has been added to our knowledge of the condition to provide an adequate explanation of its pathogenesis. This is probably the main reason for the difficulties encountered in achieving an entirely satisfactory operative procedure. Our experience has led us to consider the Heyrovsky procedure with slight modifications to be the one of choice. I think the point that Dr. Sweet has made with regard to placement of the diaphragm in relation to the stomach is important, because it may help prevent regurgitation and the occurrence of esophagitis. Like others, we have observed the development of esophagitis and hemorrhage following operation, but in our hands it has occurred rather infrequently. It should be realized, however, that these complications also occur in some patients who have had no operative treatment.

The final point I would make is that, so far as etiology is concerned, I have serious doubt that this condition is related to hypertrophic pyloric stenosis or to mega-esophagus. This, too, is an idea which has been revived and abandoned from time to time, and to revive it again requires additional facts to support it.

DR. W. B. CRANDELL, White River Junction, Vermont.—About a year ago there appeared in the British Medical Journal an article by a group from Budapest on the effect of 100 c.c. of 1 per cent oral procaine on relaxing the pylorus and pylorospasm either primary or secondary to other organic disease. This was studied by roentgenogram and fluoroscopy with barium techniques and found quite successful in bringing about relaxation in a good percentage of nearly 1,500 cases that were studied. In July of last year we began a similar study and found it helpful in preparing patients who had pylorospasm associated with pyloric obstruction for operation. It was not helpful in those people who had organic stricture or carcinoma.

About two months ago we became interested in using it in esophageal disease and in cases with symptoms associated with hiatus hernia or duodenal ulcer. We did have recently one case with cardiospasm, and I would like to describe our experience with that. This was a 28-year-old man who was admitted with an eight months' history of intermittent vomiting after meals. He had had daily vomiting for two months prior to admission. He had epigastric and substernal pressure and obtained relief after vomiting. There was no relief from antacids, and he had lost 30 pounds during this period. Roentgenograms revealed cardiospasm.

(Slide) Esophagoscopy did not show any ulceration or marked esophagitis. There was slight but not much relief with belladonna and amphogel. A few days after admission he was started on oral procaine, 100 c.c. of 1 per cent solution a half hour before meals three times a day. At noon the first day he took his first second helping in several months. Two days later he had noticed marked improvement and was essentially asymptomatic. He gained some seven pounds in ten days. We tried to get some objective measurement of the effect of the oral procaine by having him fluoroscoped and x-rayed, using a stopwatch. The roentgenogram on the left shows what was found four minutes after a barium meal. The radiologist tells us that the level is at the level of the pulmonary artery. He was allowed to clear his esophagus and then was given 100 c.c. of 1 per cent procaine, followed in fifteen minutes by another swallow of barium which the radiologist tells us, five seconds later, is already down to this point, just above the diaphragm. Four minutes afterward, however, there was still some barium in the lower end of the esophagus.

Our experience with these few cases leads us to think that oral procaine might be useful in conjunction with antacid treatment for spasm of the lower end of the esophagus associated with ulcer, tumor, or cardiospasm in preparing patients for operation, particularly those who are malnourished.

DR. ARTHUR M. OLSEN, Rochester, Minn. (closing).—I should like to thank the discussors for their kind remarks and constructive criticism. In view of the fact that many papers concerning surgical management of cardiospasm have been published recently, we believed that attention should be called to the fact that the majority of patients can be treated satisfactorily by forceful dilatation of the cardia. As Dr. Tuttle* has emphasized, dilatations must be performed expertly. It is our opinion that anyone who is proficient in the techniques of bronchoscopy and esophagoscopy also should be capable of treating esophageal obstruction by the method of dilatation. Surely dilatation therapy should be tried in practically every case before operative intervention.

Dr. Sweet is certainly right when he states that the actual obstruction is located above the cardia in the lowermost segment of the esophagus. The term "cardiospasm" does not accurately describe the condition, but it has been used for so long that we find it difficult to change the terminology. There does appear to be a physiologic sphincter in the lower part of the esophagus which does not open readily. Although the word "achalasia" may come closer to describing the nature of the disease, it seems likely that "cardiospasm" will persist in medical literature for some time to come.

*Dr. Tuttle's discussion was not returned.—Editor.

THORACOPLASTY COMBINED WITH RESECTION FOR PULMONARY TUBERCULOSIS*

WILLIAM S. CONKLIN, M.D., JOHN E. TUHY, M.D. (BY INVITATION), AND JEROME T. GRISMER, M.D. (BY INVITATION)
PORTLAND, ORE.

PULMONARY resection has been accepted as an indispensable adjunct in the treatment of an increasing number of cases of pulmonary tuberculosis. It is extremely important therefore, to determine how the complications and unfavorable sequellae of this type of surgery may best be prevented and managed. Because of the unpredictable behavior of the disease, resections for tuberculosis have involved greater hazards than those for most other types of bronchopulmonary pathology. Specific complications include postoperative spreads, reactivation or progression of pre-existing lesions in nonresected lung, tuberculous bronchitis and ulceration in the stump of an amputated bronchus, and tuberculous empyema. Bronchopleural fistula is a greater hazard not only because tuberculous involvement of the bronchus may interfere with healing and predispose to perforation or rupture of the bronchial stump, but also because tuberculous foci may be traversed in dividing incomplete fissures or in separating the segments of a lobe. Antibiotics have markedly reduced, but have not eliminated, these complications of pulmonary resection for tuberculosis.

In all pulmonary resections it is important to preserve as much respiratory function as possible. When a lung, or part of a lung, has been removed the remaining lung tissue becomes distended or emphysematous, as its volume is increased to fill the relatively fixed volume of the thoracic cavity. Overdistended lungs are considered to function with impaired efficiency. It is also believed that residual tuberculous foci are more likely to manifest reactivation or progression as overdistention develops. Following pneumonectomy, space-filling substances (air, oil, plastic spheres, plastic sponge, etc.[2]) have been introduced into the pleural cavity to prevent such overdistention, and also to prevent excessive mediastinal displacement and the cardio-circulatory embarrassment which may result. But the use of space-filling materials in the pleural cavity following resection of only part of a lung does not seem practicable nor can it be expected to affect the incidence or management of fistula and empyema following any lung resection except, possibly, in an unfavorable manner.

When only a lower lobe or basal segments of a lower lobe are resected, space-filling does not present as great a problem. The hemidiaphragm tends to rise and obliterate the space. And this can be promoted readily, when necessary, by a phrenic nerve interruption, by pneumoperitoneum, or both.

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Many surgeons believe that a thoracoplasty should be performed routinely two or more weeks following most resections, particularly following removal of a tuberculous upper lobe or lung. The thoracoplasty, thus performed, tends to relieve lung distention and permits the mediastinum to return to a more normal position. It probably decreases the incidence of postoperative spread and exacerbation. Undoubtedly it helps to prevent the late development of bronchopleural fistula and empyema and aids in the control of these serious complications when they occur.

Some surgeons recommend that thoracoplasty be performed in advance of a contemplated resection. A few advocate performance of resection and thoracoplasty at the same operation. Whether performed earlier, concomitantly, or later, the thoracoplasty at present seems to offer the best solution to some of the problems connected with resection of a lung, or of an upper portion of a lung, particularly in patients with pulmonary tuberculosis. Granted the desirability of thoracoplasty for these patients, the authors propose to explore the advantages of the combined operation as borne out by their own experiences and those reported by others.

In May, 1948, we resected the left lung of a 39-year-old woman who had had a previous left thoracoplasty. Believing that the thoracoplasty should be extended, we decided to remove segments of three more ribs after the lung had been removed and before completion of the operation. Resection of these additional rib segments was well tolerated. This experience suggested to us that patients undergoing upper lobe lobectomy could properly have a partial thoracoplasty performed at the same time, without appreciably increasing the hazards of the surgery. When we next resected a tuberculous left upper lobe (July, 1948), we performed a five-rib thoracoplasty immediately. The additional surgery did not affect the patient adversely and the postoperative course was remarkably smooth.

We now plan most resections with the idea of a combined procedure in mind. Our resections are followed immediately by partial thoracoplasty when the advisability or need for thoracoplasty seems evident and when the patient's condition permits. We are convinced that definite advantages accrue.

The first combined pneumonectomy and thoracoplasty of which we have knowledge was the historic resection for carcinoma of the lung performed by Evarts Graham in 1933. At the time of pneumonectomy ribs three to ten were resected and later the first two ribs were removed in order to collapse a small empyema cavity. The empyema would doubtless have been a much more serious complication if the pleural dead space had not been largely obliterated at the time of the original operation. Dr. Graham performed thoracoplasty at the time of pneumonectomy in his next five or six cases, after which he discontinued this practice as a routine. However, he and Dr. Burford still frequently perform thoracoplasty in conjunction with pneumonectomy for tuberculosis in order to diminish the possibility of tuberculous empyema.[7]

The first publication devoted to the subject of combined resection and thoracoplasty was that of Iverson, Roland, and Skinner,[4] who recorded three

cases of pneumonectomy for tuberculosis followed by immediate thoracoplasty. Seven additional cases were reported by two of these same authors at the 1949 meeting of the American Association for Thoracic Surgery.[5]

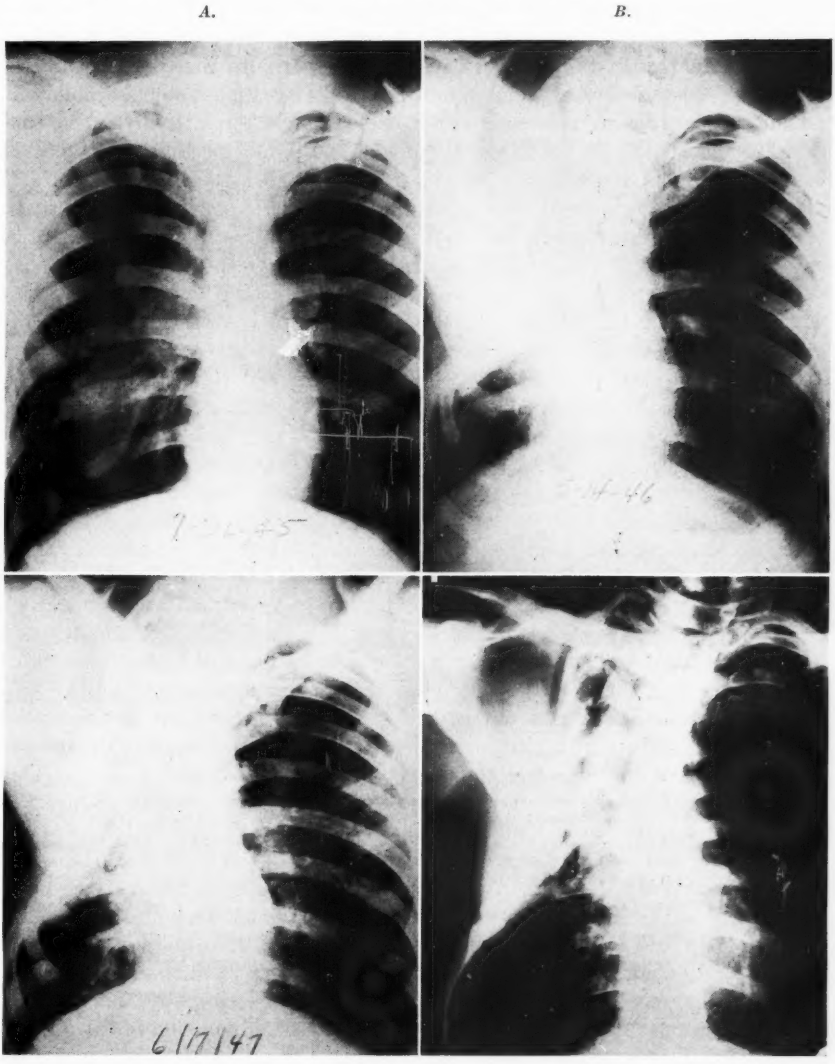


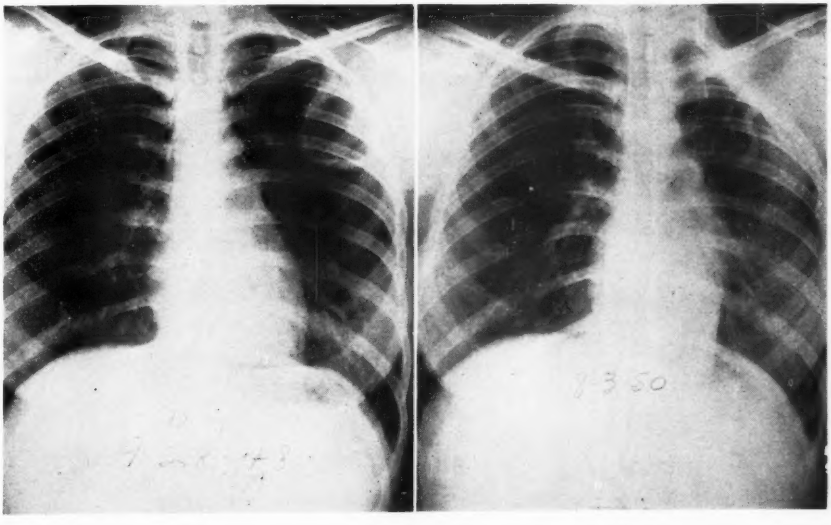
Fig. 1.—H. B., *A*, Inadequate pneumothorax with large cavity in atelectatic upper lobe. *B*, Upper lobe lobectomy, followed by early thoracoplasty in two stages. First rib not resected. *C*, Bronchogenic tuberculous dissemination. *D*, Bucky roentgenograph shows evidence of empyema and bronchopleural fistula (late development) which were, apparently, the source of bronchogenic spread. The empyema and fistula were eventually controlled by drainage and revision thoracoplasty, including the first rib. The tuberculous spread responded to antibiotic therapy.

Iverson and Skinner had been impressed by the relatively benign postoperative course following pulmonary resection when a thoracoplasty had previously been performed, despite the increased technical difficulties of post-thoracoplasty resection. They had also been disturbed by the fact that some patients would refuse a recommended thoracoplasty while convalescing from a pneumonectomy. In the light of their experiences with the combined operation they concluded that combining thoracoplasty with pneumonectomy is advantageous when overdistention of the contralateral lung is particularly undesirable, as in the presence of emphysema, and when postoperative pleural complications are anticipated. They emphasized the points that when thoracoplasty has been performed with pneumonectomy the danger of postoperative fistula and empyema is decreased, and the treatment of these complications is easier if they occur. They also concluded that the combined procedure resulted in less disturbance in respiratory physiology than one is likely to encounter following pneumonectomy alone. This they attributed to the weight of the scapula, combined with use of a pressure dressing over the decostalized area, rendering the mediastinum relatively stable and the cough mechanism more effective. Weight was added to their arguments for performing thoracoplasty at the time of pneumonectomy, rather than later, by quoting from Minor[6]: "When a thoracoplasty is performed over a closed pleural space containing air, or fluid, or both, a rapid increase in intrapleural pressure results. Highly positive pressure upon the heart and mediastinum produces a form of shock which may be rapidly fatal." They also quoted Bailey[1]: "Since two of the five deaths were subsequent to elective thoracoplasties performed merely to obliterate the pleural space, it can well be imagined that we are on the lookout for a method of avoiding this secondary operation."

Our material and technique have differed from those of Iverson and Skinner. In the first place, while they used the combined procedure only where total pneumonectomy was performed, we have used it more often with upper lung resections than with pneumonectomy. The above authors routinely left the first rib (or the first and second ribs) intact, as advocated by Overholt in postresection thoracoplasties. However, we have preferred to remove the uppermost ribs, believing that this helps to obliterate the pleural dead space more rapidly and prevents significant displacement of the trachea and superior mediastinum (Figs. 1 and 2). Iverson and Skinner have routinely drained the pleural space in patients who have had combined pneumonectomy and thoracoplasty, but we have not done so. There seems to be more rationale for drainage following the combined operation than after pneumonectomy alone, since the thoracoplasty, supported by a pressure dressing, will prevent excessive mediastinal shift, and drainage will promote obliteration of the pleural cavity. We routinely use one or two drainage tubes when lobectomy or segmental resection has been combined with thoracoplasty.

A paper on upper lobe lobectomy and concomitant thoracoplasty, by Samson, Dugan, and Harper, was published in December, 1950.[8] The authors report seventeen such operations with one death and no postoperative complications. They also report nine pneumonectomies and concomitant thoracoplasties

with no complications or deaths. While our technique differs somewhat from theirs, our operative material and results have been similar and we seem to be in complete agreement as to the advantages of the combined procedure. The usual indications for resection were present in most of the patients who had concomitant thoracoplasty and resection in our series, though some of the resections may be considered "elective," in that other surgeons might have recommended thoracoplasty alone.



A. *B.*

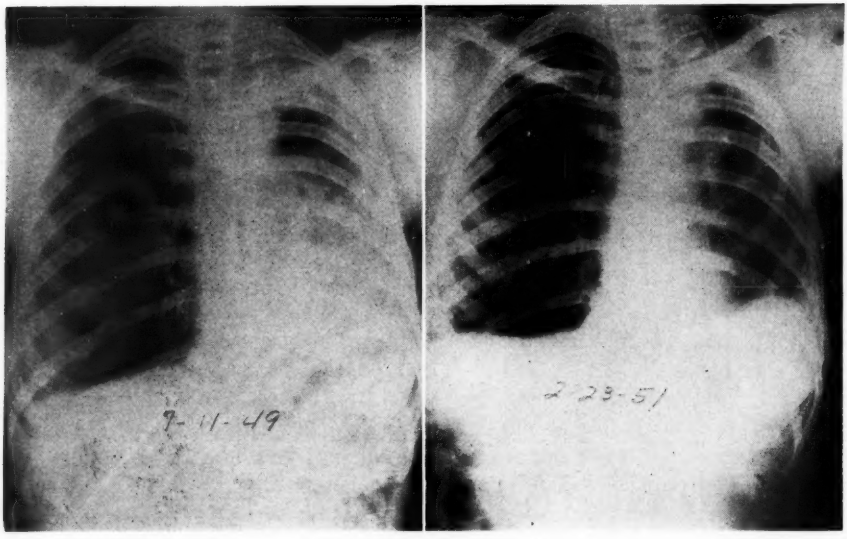
Fig. 2.—H. K., *A*, Admission roentgenograph. "Tension" cavity in left upper lobe. *B*, Following resection of left upper lobe with concomitant four-rib thoracoplasty.

TECHNIQUE

Standard methods of pre- and postoperative management were used. The Overholt face-down position was employed in only one operation. The exposure for resection of the upper ribs was found to be poorer than in the lateral decubitus position, which the authors prefer. Anesthesia was induced with Pentothal-curare solution injected intravenously, and continued with cyclopropane, nitrous oxide, ether, and oxygen, administered by endotracheal tube.

In our earlier cases the thoracotomy incision was made through the periosteal bed of the fifth or sixth rib. In upper lobe lobectomies it soon became evident that extensive resection of these ribs was generally not required for a thoracoplasty designed merely to obliterate the pleural dead space. We then found that, working through the same skin incision, we could limit resection of ribs to those segments directly overlying the portion of the lung to be removed.

Our revised technique involves the removal of a short posterior segment of the fourth rib, the pleural cavity being entered through its periosteal bed. The incision is extended along the fourth intercostal space, after dividing the fourth intercostal neurovascular bundle between suture ligatures. The fifth rib and interspace are used when a five rib thoracoplasty is contemplated. The exposure thus obtained is generally adequate for any type of resection. It can be increased by resecting at once that portion of the third (or fourth) rib, usually its posterior third, which would be resected for the proposed thoracoplasty. The trapezius and rhomboid muscles are divided either to a limited extent, or not at all.



A. *B.*

Fig. 3.—C. H., *A*, Patient has had left artificial pneumothorax, pleural exudate, and obliterative pleuritis. Sputum, positive. *B*, Eighteen months following resection of contracted left upper lobe, decortication of left lower lobe, and concomitant thoracoplasty. Patient clinically and subjectively well for the first time in ten years. Sputum, negative.

After the significantly involved lung segments have been resected, adhesions to the remainder of the lung are separated and decortication is performed if indicated (Figs. 3, 6, and 10). The patient's condition is then evaluated and it has almost always seemed safe and proper to complete the thoracoplasty by resecting portions of the ribs remaining above, including the first two ribs forward to, or almost to, the cartilages.

With the pleural cavity open, following the pulmonary resection, we feel that we can determine more accurately how much of each rib should be removed in order to achieve the desired amount of chest wall collapse. The extent of the thoracoplasty can be adapted to the remaining portion of the lung, without collapsing conserved lung unless one specifically wishes to do so because of residual tuberculous foci. We wish to emphasize that the open

thorax provides adequate exposure for completion of the upper phase thoracoplasty through an incision that does not involve extensive division of the interscapular shoulder muscles. The posterior rib stumps are purposely left long. The transverse processes and erector spinae muscles are not disturbed. This modified type of thoracoplasty seems to provide the desired amount of collapse with minimal postoperative scoliosis, chest deformity and impairment in function of the shoulder girdle.

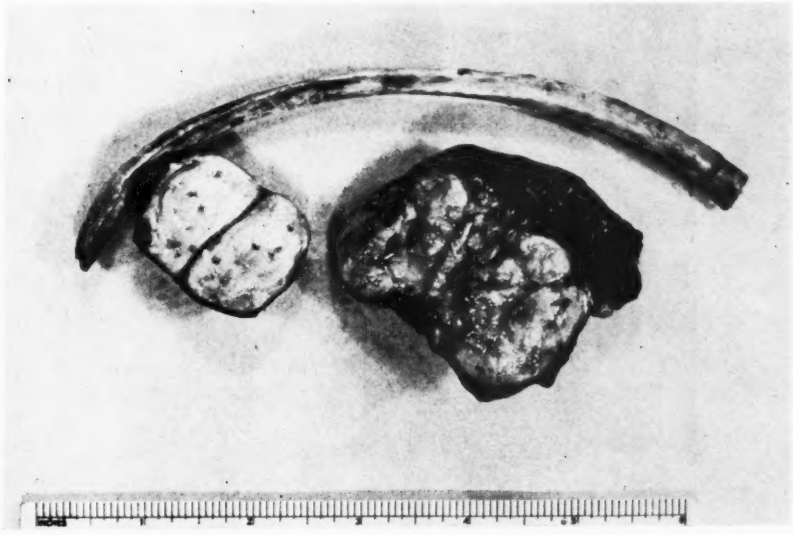


Fig. 4.—E. L., *A*, Admission roentgenograph. *B*, Body section radiograms showing a tuberculous granuloma with central necrosis in the right upper lobe (11 cm. cut) and a contracted superior segment of the right lower lobe with cavities (4 cm. cut). *C*, Following bilateral artificial pneumothorax and antibiotic therapy resection of the superior segment of the right lower lobe and of the "tuberculoma" in the right upper lobe (local resection) has been performed. Remainder of the lung at surgery showed no residual gross involvement and, when expanded, its volume was such as to make thoracoplasty appear unnecessary. Left pneumothorax has been maintained and sputum is negative. Resection of "tuberculoma" in left lung may be advisable.

In one of our patients who had mixed infection empyema, bronchopleural fistula and tuberculous bronchiectasis, eight ribs were removed at the time of total pleurectomy and pneumonectomy. Ordinarily, however, a four or five rib thoracoplasty is performed and, if additional collapse is deemed advisable, a second stage lower phase thoracoplasty is carried out two or three weeks later.

CLINICAL MATERIAL

We have not chosen patients for concomitant resection-thoracoplasty by any fixed protocol. Usually the preoperative plan, tentatively recommended at staff conference, has been carried out without alteration. In some patients thoracoplasty is considered unnecessary because the nonresected portion of the lung fills the pleural cavity sufficiently to obviate excessive overdistention and mediastinal displacement. This is often true following resection of

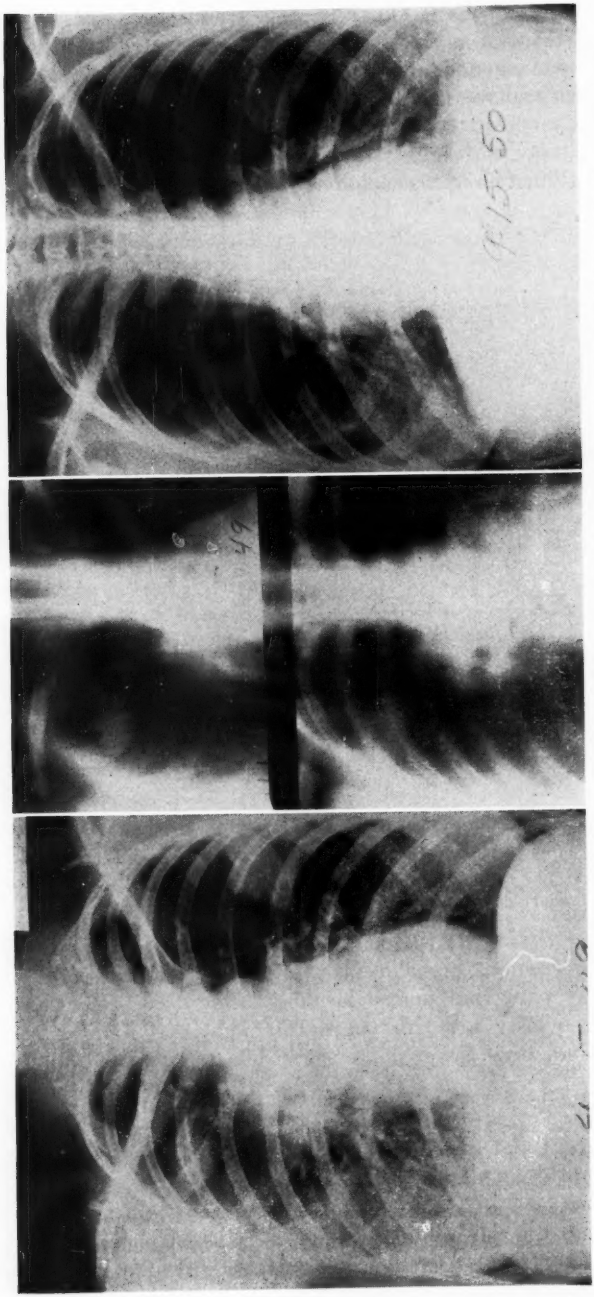


Fig. 4 *D.*—E. L. Surgical specimens. Today, resection of the long rib segment would have been avoided.

a markedly contracted lobe or following segmental and local resections, as for "tuberculoma" (Fig. 4). The combined procedure may sometimes be chosen at the time of surgery, because expansion of the remainder of the lung is poorer than anticipated (Fig. 10) or because it is felt that thoracoplasty provides greater protection for tuberculous lesions which are grossly evident, but not resected. In a few patients we have contemplated the combined procedure, but postponed the thoracoplasty because, following resection, the patient's condition did not warrant the additional operative trauma and blood loss.

We have performed thirty-eight combined resection-thoracoplasties between May, 1948, and April, 1951. There were twenty-eight women and ten men, all white, ages ranging from fifteen years to fifty-seven years. Most of the patients had far-advanced bilateral disease and had had one or more previous hospitalizations for tuberculosis. About two-thirds had had previous collapse therapy. One patient in the lobectomy group and two in the pneumonectomy group had had a previous apical thoracoplasty which was extended at the time of resection. One patient, listed with the upper lobe resections, had previously had the homolateral middle and lower lobes removed.

Of the thirty-eight patients, six were subjected to pneumonectomy. In twenty-nine an upper lobe was removed and in twelve segmental resection was performed alone or in conjunction with lobectomy.

COMPLICATIONS

The complications are listed in Table II.

Bronchopleural fistula occurred twice. In the first of these the fistula became apparent on the thirteenth postoperative day. This was controlled by

TABLE I

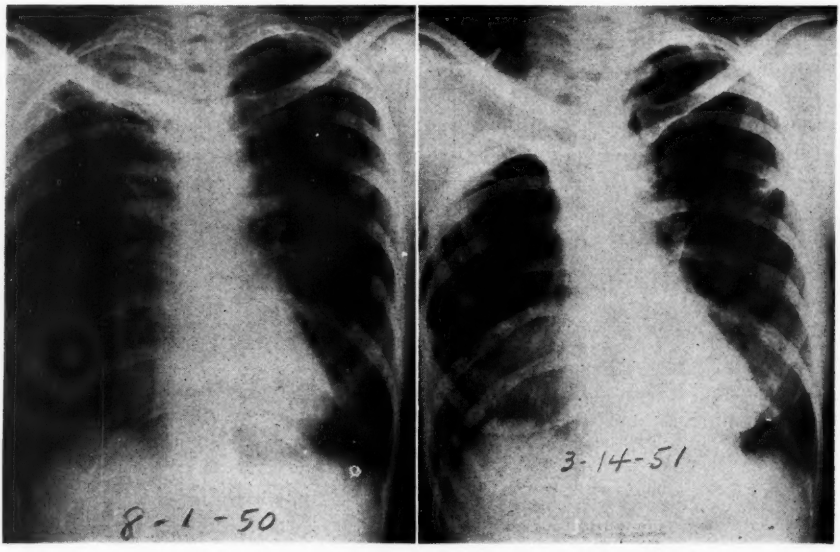
	NO. OF PATIENTS
Upper lobe only	18
Upper lobe, superior segment of lower lobe	8
Same, plus right middle lobe	1
Right upper and right middle lobes	2
Segment of upper, only	2
Superior segment of lower, only (Fig. 10)	1
	32
Pneumonectomy (left, 5; right, 1)	6
	38

TABLE II. POSTOPERATIVE COMPLICATIONS

	LOBECTOMY	PNEUMONECTOMY
Bronchopleural fistula	2	
Early contralateral spread	1	
Atelectasis	1	
Recurrent nerve palsy		1
Pulmonary edema, atelectasis, right heart failure	1 (died)	
	5	1

introduction of an intercostal tube which was left in place for five days. Clinically there had been no evidence of empyema and the patient's convalescence was otherwise uneventful (Fig. 5).

The second bronchopleural fistula occurred in a recent case and this was further complicated by an empyema. The combined operation involved resection of the apical segment of the right upper lobe and segments of only the first three ribs, a slight departure from our usual technique. Since the original surgery, decortication for the empyema and resection of two more ribs has been performed in two stages. The patient is now convalescing satisfactorily.

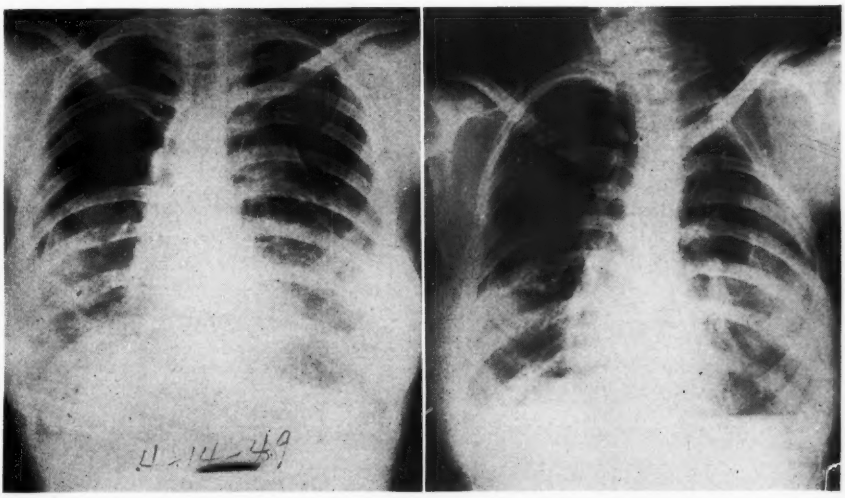


A. *B.*

Fig. 5.—E. F., *A*, Contracted upper lobe containing thick-walled cavity. *B*, Following resection of right upper lobe and concomitant thoracoplasty. Contralateral disease now appears stable. Sputum, negative.

One patient had an early postoperative spread, or exacerbation, in the contralateral upper lobe where pre-existing tuberculous lesions had been considered stable. This complication responded promptly to antibiotic therapy and the patient is clinically well more than one year following her discharge from the hospital. One patient had a temporary atelectasis following surgery which responded to aspiration of the tracheobronchial tree with no further difficulties. In a patient subjected to total pleurectomy and pneumonectomy for chronic mixed infection empyema with bronchopleural fistula and tuberculous bronchiectasis, present for many years, the left recurrent laryngeal nerve inadvertently was injured or severed. Left recurrent laryngeal nerve palsy has persisted.

The one death occurred in a 36-year-old white man, following resection of the right upper and middle lobes and a five-rib thoracoplasty for far-advanced cavitary disease. His condition was satisfactory until the fourth postoperative day when he developed abdominal distention and progressively increasing dyspnea. These did not respond to the usual management and he died twelve hours later. An autopsy revealed "acute massive edema of the left lung, bilateral pulmonary tuberculosis, purulent tracheobronchitis, atelectasis of the right lower lobe, dilatation of the right heart and paralytic ileus." It is believed that this death might have been avoided had his airway been cleared and his ileus treated more promptly.



A. *B.*

Fig. 6.—L. C., *A*, Prolonged bilateral artificial pneumothorax has been complicated by tuberculous exudate on both sides. Sputum, positive. *B*, Following resection of apical-posterior segment of left upper lobe, decortication of the remainder of the lung, and concomitant four-rib thoracoplasty.

RESULTS

The thirty-eight cases presented are too few for statistical analysis or for comparison with a series of similar cases subjected to resection alone or to resection with previous or subsequent thoracoplasty. The follow-up has not been long enough to draw conclusions about the long-term results. However, one can obtain an idea of the early postoperative morbidity from the data at hand.

There is only one patient who has a positive sputum and this is attributed to pre-existing contralateral disease. She is not hospitalized at present, but we consider her a candidate for concomitant right decortication, segmental resection and thoracoplasty, corresponding to the operation which she had performed two years ago on the left (Fig. 6). One patient is dead (see above). If one were to include the nine who are still hospitalized (and in all of them

TABLE III. RESULTS

	ALIVE SPUTUM NEG.	ALIVE SPUTUM POS.	STILL IN HOSPITAL	DEAD
Lobectomy	30	1	6	1
Pneumonectomy	6	–	3	–
	36	1	9	1

Follow-up:	
More than two years	8
Between one and two years	10
Less than one year	19
Dead	1
	38

the prognosis is considered good) we find that thirty-six or 95 per cent have negative sputum and are candidates for permanent arrest of their disease.

We are impressed that these results, admittedly tentative, compare favorably with the early results of thoracoplasty alone or with those for any other type of therapy for tuberculosis. In evaluating this statement it should be remembered that most of the patients in this series had previously been subjected to other types of therapy without success and that most of them had a type of lesion for which resection is considered mandatory. Since thoracoplasty is considered advisable as an adjunct to resection for pulmonary tuberculosis, and since it does not appear to increase the hazard when, in selected cases, it is performed at the same time rather than separately, there seems to be ample justification for the combined operation.

DISCUSSION

We do not attempt, in this paper, to discuss the indications for pulmonary resection in tuberculosis. It is pertinent, however, that the authors try to avoid sacrificing an entire lung simply because the tuberculous pathology is found, at operation, to be more widespread than anticipated from preoperative roentgenographic interpretations. We prefer to abandon a resection in favor of some other type of therapy if, at thoracotomy, we find that a more extensive resection than was considered to be well within the patient's tolerance would be necessary. In general, we try to limit the resection to those portions of a lung that are completely destroyed or that contain a type of lesion notoriously resistant to medical and collapse therapy. It is our impression that remaining lesions in the same and contralateral lung will actually respond better to rest and antibiotics after the major pathology, such as caseating lesions and bronchiectasis, has been removed. This is perhaps especially true when concomitant thoracoplasty prevents distention of the remainder of the lung (Fig. 5).

It may be argued that in several instances where we have performed a combined resection-thoracoplasty it would have been preferable to perform the thoracoplasty first. It is possible that in some of these the thoracoplasty alone would have served to control the disease, but preoperative studies always made us think that such a result was quite unlikely. Certainly a pri-

mary thoracoplasty would have had to be considerably more extensive than that combined with resection, and it would generally have involved two or more staged operations. We are of the opinion that in each instance the com-

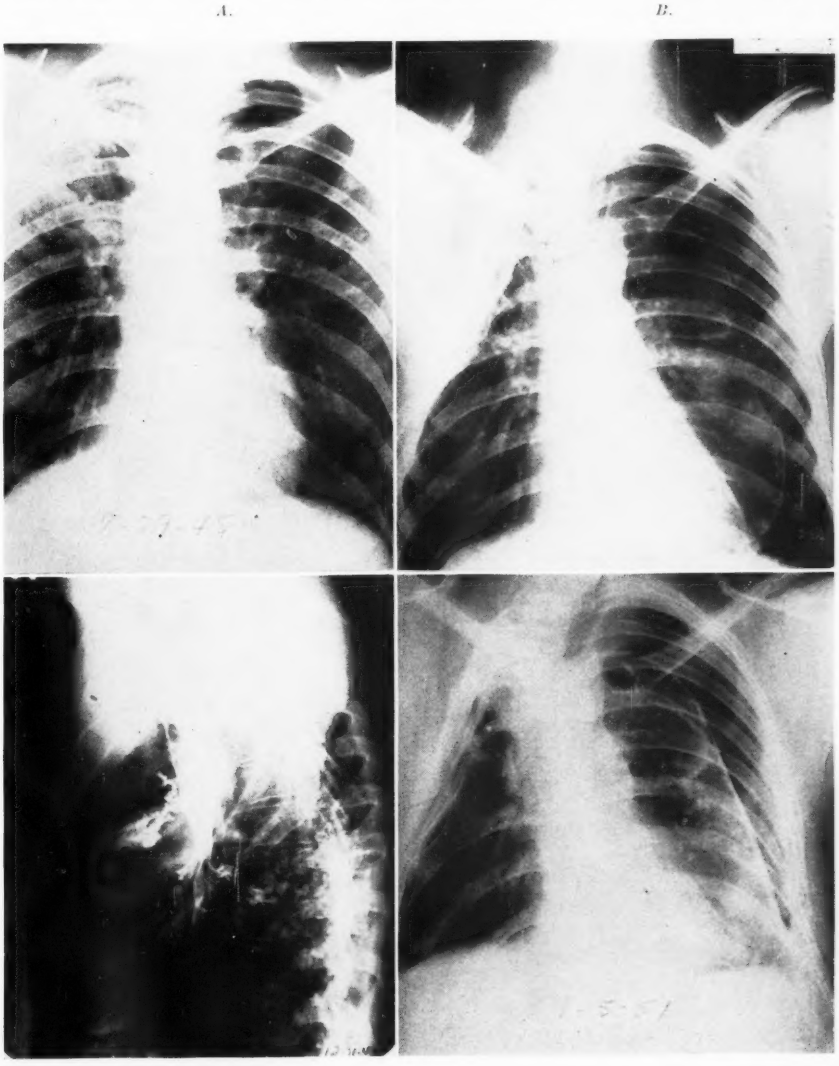


Fig. 7.—E. B., *A*, Admission roentgenograph. *B*, Since primary thoracoplasty on the right did not convert sputum, a left artificial pneumothorax was induced. Sputum, still positive. *C*, Tuberculous bronchiectasis demonstrated in right upper lobe by bronchography. *D*, Sputum converted following resection of right upper lobe.

Comment: Recent experiences suggest that this patient would have had markedly decreased morbidity and far greater conservation of function had combined resection-thoracoplasty, supported by antibiotic therapy, been available to him. Compare with Fig. 5.

bined operation has left the patient with more respiratory reserve, more shoulder function and less deformity than a standard thoracoplasty would have entailed.* We also are inclined to believe that the combined operation might have decreased the morbidity and eliminated the need for extensive bi-

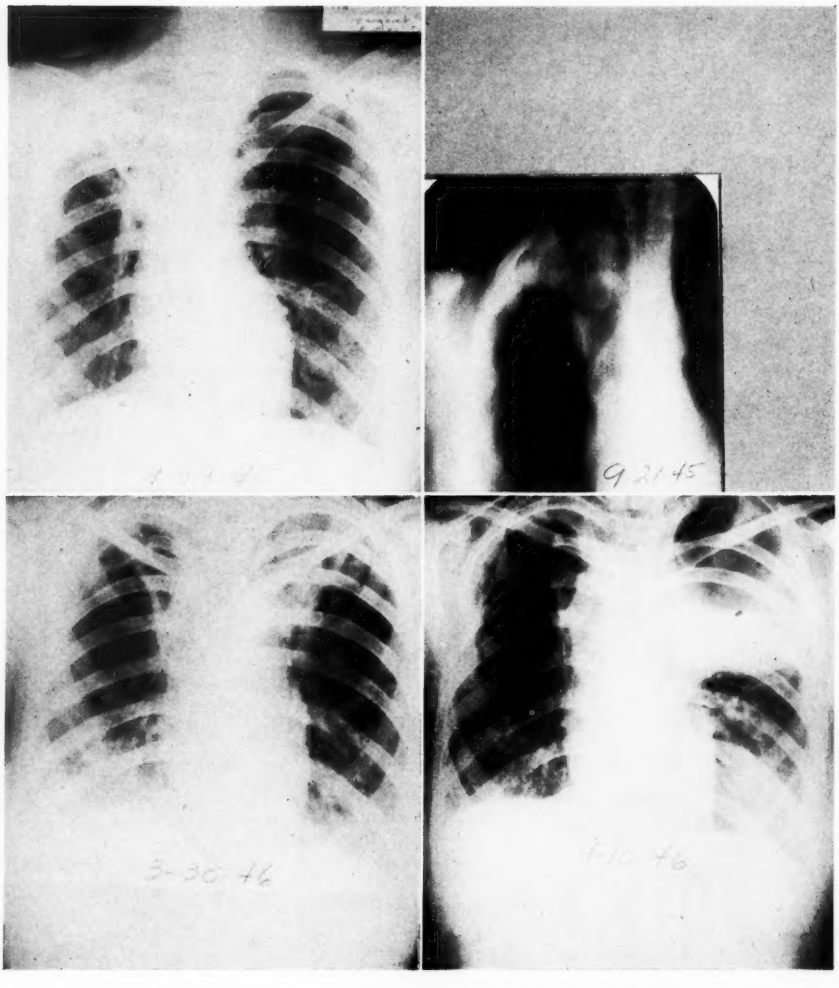
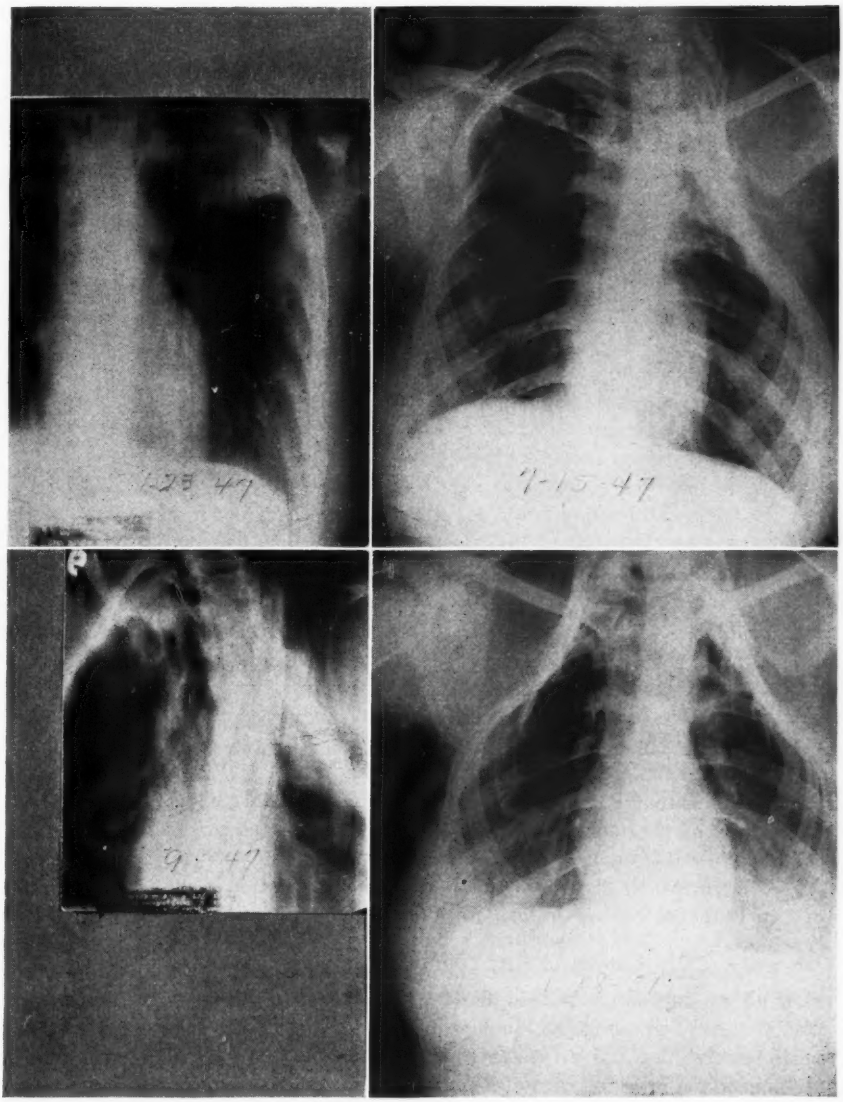


Fig. 8.—M. Y., *A*, Admission roentgenograph. *B*, Body section radiogram showing contracted upper lobe, bronchiectasis, stenosis of right upper lobe bronchus. *C*, Following resection of right upper lobe. Postoperative spread to left upper lobe. *D*, Following left extrapleural pneumothorax.

*Samson and co-authors[3] state: "While facilities are lacking to substantiate this belief, it is the authors' impression that there is less reduction in the vital capacity following lobectomy-thoracoplasty than with a thoracoplasty which would have been sufficient to control the disease."

E. *F.*



G. *H.*

Fig. 8,—*E*, Sputum, still positive. Body section radiogram shows small residual cavity under extrapleural pneumothorax. *F*, Following left thoracoplasty. *G*, Oblique body section radiogram shows cavity in superior division of right lower lobe. *H*, Over three years following right thoracoplasty. Patient has arrested tuberculosis.

Comment: It is believed that this patient's tuberculosis might well have been promptly controlled today, by combined resection-thoracoplasty and antibiotic therapy without having to be subjected to the extensive collapse procedures illustrated. Note the overdistention of the right lower lobe following lobectomy, only partially relieved by subsequent thoracoplasty.

lateral collapse therapy in some of our earlier cases who had primary thoracoplasty, or who had resection without concomitant or early thoracoplasty. Examples are illustrated (Figs. 7 and 8).

A thoracoplasty performed in anticipation of a later resection subjects the patient to an additional major operative procedure, which we believe should be avoided. Following a thoracoplasty resection becomes technically more difficult and it is harder to dissect and free adhesions in the costovertebral gutter without tearing into infected lung tissue or a cavity. We also feel that, with the protection provided by antibiotics, significant postoperative spreads may, in years to come, be shown to occur less frequently following resection than following thoracoplasty, because the chief source of bacilliferous sputum is not merely collapsed, but removed.

An advantage in performing thoracoplasty in conjunction with lobectomy rather than later, suggested by Himmelstein, Berry, and Read,[3] is that the remainder of the lung becomes adjusted to the residual pleural space before its motility is limited by pleural adhesions. If the thoracoplasty is delayed and there has been an opportunity for adhesions to develop, the thoracoplasty will serve mostly to collapse the upper portion of the remaining lung tissue, leaving the rest of it overdistended (Fig. 8).

On the basis of our limited experience with the procedure we have tentatively adduced the following other advantages of the combined operation over resection and thoracoplasty performed separately:

1. The thoracoplasty need not be as extensive or radical as when it is performed before or after a subtotal pulmonary resection. Hence, there is less deformity, less disturbance to the function of the shoulder girdle, and probably less disturbance to respiratory function. If necessary, the thoracoplasty can later be revised and extended to control lesions in the nonresected portion of the lung though this has not as yet been necessary in any of our cases.

2. The extent of the thoracoplasty can be conformed rather accurately to the size of the pleural dead space before overdistention and adherence of the remainder of the lung have occurred.

3. It is probably safer, with the combined operation, to conserve portions of the lung containing lesions for which resection ordinarily would not be considered.

4. The combined procedure allows better exposure of the uppermost ribs through an incision which is shorter than that generally used for thoracoplasty alone. There is less damage to the muscles of the shoulder girdle and postoperative deformity (scoliosis) is minimized by preserving the muscles of the spine.

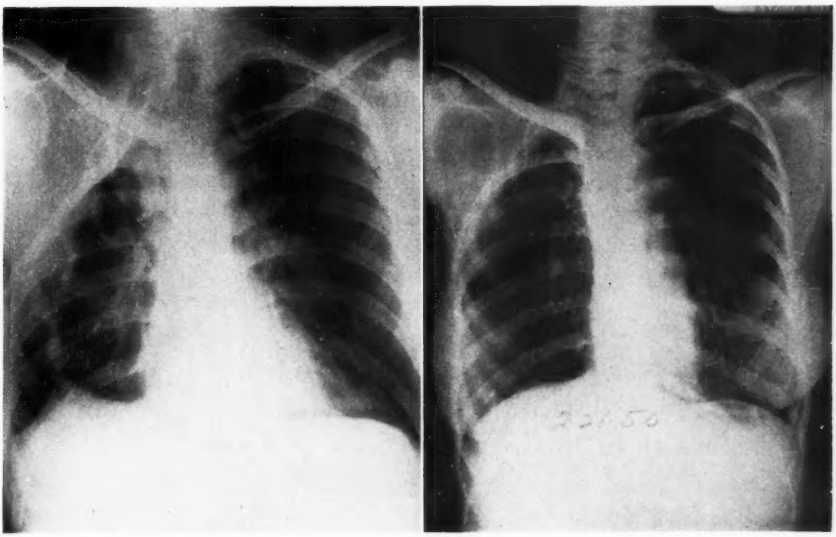
5. Earlier, more rapid obliteration of the pleural dead space is promoted, decreasing the hazards of bronchopleural fistula and empyema.

6. The concomitant operation eliminates one major procedure with its attendant risk and expense.

7. The presumed benefit of thoracoplasty is assured to the patient who might refuse a second operation.

8. Eliminating an additional operative procedure decreases the load on the hospital's surgical facilities and increases the number of patients who may be treated surgically in a given period of time.

Since we have susbstituted an intercostal incision for an incision through the periosteal bed of a long segment of resected rib, we believe that more function has been preserved by maintaining, to a greater extent, the integrity



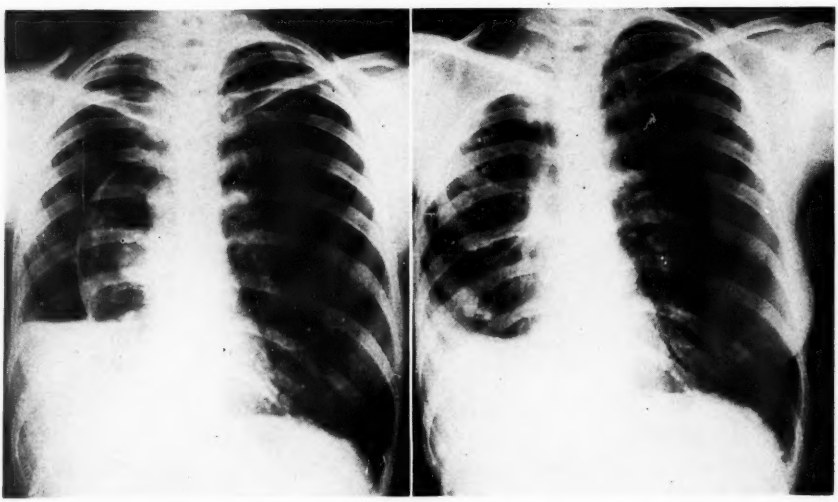
A. *B.*

Fig. 9.—E. S., *A*, This patient, in March, 1948, had first a right upper lobe lobectomy, with a thoracotomy through the periosteal bed of the fifth rib. Nine days later a thoracoplasty, involving the first four ribs, was performed. *B*, V. K. Combined resection-thoracoplasty, September, 1950. Exposure by technique described in text, with thoracoplasty confined to graded segments of first four ribs.

of chest wall structures over the nonresected portion of the lung. The differences are suggested, to a degree, by comparing the roentgenograph of a patient who had first a lobectomy (exposure through the bed of the fifth resected rib) with that of a patient who had a combined operation with use of an intercostal incision for exposure (Fig. 9). The comparison is not accurate nor are our impressions objectively substantiated; but it does seem that chest wall integrity and respiratory function are more dependent on intact, flexible ribs than on the loss due to dividing intercostal muscles.

Patients who have had prolonged pneumothorax therapy, continued or discontinued, and whose pulmonary tuberculosis is still uncontrolled, are frequently candidates for resection of residual cascating lesions and decortication of the remainder of the lung. In these patients one should not neglect the value of performing thoracoplasty at the same time in order to conform the size of the pleural cavity to the volume of the remaining decorticated portion of the lung (Figs. 3, 6, and 10).

Since thoracoplasties are sometimes advisable or mandatory following resections for nontuberculous suppurative or neoplastic disease it is obvious that some of these patients may also be candidates for the combined operation under consideration. We have performed thoracoplasty at the time of resection in a few such patients, seemingly to advantage; but the discussion here is concerned primarily with resections for pulmonary tuberculosis.



A. *B.*

Fig. 10.—E. B., *A*, Right artificial pneumothorax since 1937. Pleural exudate positive for tubercle bacilli. Sputum was positive in July, 1949. *B*, Following decortication, resection of superior segment of right lower lobe (contained a cavity) and concomitant four-rib thoracoplasty (March, 1950). While very little lung was resected, the remainder of the lung, long collapsed, did not adequately fill the pleural cavity. Thoracoplasty was therefore performed at once.

In conclusion it may be stated that, with the exception of one patient who died, and one patient who required two subsequent thoracotomies for decortication and for closure of bronchopleural fistulae (but who now is convalescing satisfactorily), the combined operation of lobectomy or segmental resection with thoracoplasty has been well tolerated. Another patient had a bronchopleural fistula, but this responded promptly to intercostal tube drainage and her convalescence was otherwise uneventful (Fig. 5). The remainder of the patients appear to have made exceptionally smooth recoveries with less postoperative pain, less impairment of respiratory or muscle function and less morbidity than similar patients who have been treated by resection or thoracoplasty, alone or consecutively.

SUMMARY

1. The authors have presented their experiences with a group of thirty-eight tuberculous patients in whom pulmonary resection and thoracoplasty were performed at the same operation.

2. There was one postoperative death in the thirty-two patients who had upper lung resections, none in the six who had pneumonectomy and thoracoplasty.

3. The combined operation seems to be well tolerated and the incidence of postoperative complications is low.

4. A number of advantages of the combined procedure over separate operations has been adduced from our experience and from the reports of others: a. Use of a modified thoracotomy incision and less extensive rib resection make for adequate exposure and for a better functional result than in the usual postresection thoracoplasty. b. The thoracoplasty collapse can be accurately conformed to the remaining portion of the lung before it becomes distended and adherent. Subtotal resection, in preference to pneumonectomy, can be undertaken with more confidence. c. The pleural dead space is promptly obliterated by thoracoplasty, decreasing the hazard of bronchopleural fistula and empyema. d. Elimination of one major procedure and its attendant risk is important to the patient and to the hospital, and patients with resection who might refuse a second operation are assured the protection of thoracoplasty.

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DISCUSSION

DR. PAUL C. SAMSON, Oakland, Calif.—Since apparently I am one of the early group of surgeons to concern myself consistently with concomitant operations, I feel that I should stand up and be counted so that if there are any who are sharpening axes I can offer another broad pair of shoulders to work on.

I enjoyed Dr. Conklin's presentation very much and his experiences parallel ours. As for our technique, we have left the first rib in and have peeled the pleura down from beneath the first rib, believing that there would be less deformity than if the first rib was removed. I became interested in combined procedures in 1949, following Skinner's report, and it seemed to me that lobectomy-thoracoplasty was more important, perhaps, than pneumonectomy-thoracoplasty. In the former, the tailoring of the chest wall to fit the remaining lobe seems to be rational and there is certainly less bronchial distortion than if phrenic nerve paralysis and/or pneumonoperitoneum is used to fill the space. I would only emphasize that the combining of thoracoplasty and resection is but one facet of the entire treatment problem in these patients. In addition to proper preoperative evaluation, including bronchoscopy with right-angle telescopic examination of the upper lobe bronchus, the proper timing of operation and the intelligent use of antimicrobial therapy, I stress

the great importance of strict bed rest, preferably for six months following resection. In the main, the majority of the delayed complications encountered in our entire resection program have been in patients who insisted upon relatively early ambulation and return to work.

Since January, 1949, Dr. Dugan and I (or our associates) have performed fifty-five concomitant resections with thoracoplasty. There was one immediate postoperative death, a 1.8 per cent mortality, and one delayed death, sixteen months after operation. There were forty lobectomy-thoracoplasties and fifteen pneumonectomy-thoracoplasties. There were no immediate postoperative complications of major concern in the entire series: No wound infections, no empyemas, and no spreads. There was one questionable reactivation which cleared up entirely in a few weeks. Of the fifty-three living patients, fifty are sputum-negative as of recent report.

A year ago I presented preliminary data on 26 of these patients before the California Trudeau Society and this report recently has been published as Dr. Conklin indicated.* The present status of these twenty-six patients whose operations were performed from fifteen to twenty-seven months ago is of interest. There were seventeen lobectomy-thoracoplasties with the one postoperative death previously mentioned. Of the sixteen living patients, fifteen are sputum-negative and working—a 94 per cent conversion rate; the sixteenth had active contralateral disease at the time of operation, which cleared, but later on activity developed a cavity and he is still positive. Of the nine pneumonectomy-thoracoplasties, eight are living and negative. Of these, six are at home and working; two developed a late basal empyema and are still in the hospital. The ninth patient was discharged immediately following surgery with a clear contralateral lung. At home, activity could not be restricted. Following a cold five months postoperatively, she developed active disease and died of progressive pulmonary tuberculosis sixteen months following operation.

DR. JAMES E. DAILEY, Houston, Texas.—My shoulders are not quite as broad as Dr. Samson's, but I could be included with the group subscribing to his opinions, if necessary.

For some time my associate Dr. Barkley and myself have felt, as Dr. Conklin has so excellently shown you today regarding thoracoplasties and resections, that the best time to perform this thoracoplasty would be simultaneously with the resection. We started a series of these cases, the first one in April, 1949. It is not as large a series as those that have been presented to you; it consists of only twenty-three cases, the youngest 6 years old and the oldest 56. Three of these were total pneumonectomies and twenty were lobectomies. It is not quite clear to me why Dr. Conklin advises against the combined procedure for lower lobe resections, inasmuch as we have felt that the elevation of the diaphragm was not quite sufficient to obliterate the space. Of the twenty lobectomies in our series sixteen were for lower lobe and four were for upper lobe disease. We had no deaths in the series and all but two immediately converted their sputum and have remained negative since then. The two that still have positive sputa had contralateral cavities and further procedures are contemplated for them.

If I had slides with me I believe I would be able to demonstrate the surprising lack of deformity in these lower lobe thoracoplasties. The effectiveness of the thoracoplasty in obliterating space cannot be appreciated very much by the postero-anterior and lateral roentgenographs, but roentgenographs in the oblique view show the depression in the thorax very well. It is possible that use of a plastic sponge might prove better for obliteration of this space after resection. We have had no experience with this. However, if thoracoplasty is chosen we would certainly subscribe to doing this procedure at the same time as the resection.

DR. CHARLES W. LESTER, New York.—I also am in favor of this procedure of thoracoplasty at the time of pneumonectomy or lobectomy. We first started using it some years ago in children because we thought that over-distension of the remaining lung produced respiratory difficulties in some instances, and we subsequently modified it to use in adults.

*Samson, P. C., Dugan, D. J., and Harper, H. P.: Upper Lobe Lobectomy and Concomitant Thoracoplasty in Pulmonary Tuberculosis, California Med. 73: 547-549, 1950.

(Slide.) This is the first case in which we used it; an 8-year-old girl who had a pneumonectomy for bronchiectasis. She has long posterior stumps and the first and second ribs are left in. It is quite adequate for an 8-year-old child but we do not think it would work with adults.

(Slide.) We therefore modified the procedure as shown here. We enter the chest through the resected fifth rib after the resection is completed—and this thoracoplasty procedure takes only about five minutes and does not add to the shock of operation—we take half the fourth rib, one-third of the third, and cut the second, leaving long posterior rib ends extending at least a centimeter beyond the transverse processes. If it is an upper lobe lobectomy that is all that is done; if it is a pneumonectomy we take half the sixth, and also cut the seventh in the same way the second is cut.

(Slide.) This is a two-year result in a 14-year-old girl who had a left pneumonectomy for tuberculosis. Two years after operation she was studied by Dr. Cournand, and she has only 16 per cent residual air, which is remarkably low. She has, however, what appears to be a little anatomic distention, although physiologically she has none.

In doing these pneumonectomies we feel that excess fluid should be aspirated early and often so as to permit the collapse to take place. If this is not done the chest wall will not collapse sufficiently.

(Slide.) This is a 23-year-old girl who had a destroyed right lung which also, as we found out afterward, had carcinoma in it. It was a long gruelling operation but the thoracoplasty was done at the end of it. The thoracoplasty procedure produced a fair amount of collapse, but there was so much blood and fibrin that we could not aspirate it properly, although at two months it looked like a very good result.

(Slide.) At eight months when the fluid absorbed, her heart had moved to the right side and the left lung had gone back to the position it occupied before operation.

(Slide.) This man had a pleuro-pneumonectomy, and shows another advantage to this thoracoplasty procedure. If you have to do a second procedure, that is, if you have to do more thoracoplasty, you can go in through an axillary incision. There is little blood loss and no shock to that procedure and if you have to close a broncho-pleural fistula there is plenty of muscle in the axillary fold to use as graft. This man opened his fistula eight months after operation. The thoracoplasty was completed through an axillary approach and the broncho-pleural fistula was closed in the same operation.

(Slide.) This man had decortication of the lower lobe and lobectomy of the upper lobe. The modified thoracoplasty was done at the same time and the chest was drained. The procedure allowed a better collapse and he has good pulmonary function.

DR. RICHARD H. OVERHOLT, Brookline, Mass.—Dr. Conklin has proposed a most worth-while subject for consideration. I should like to bring out two points: first, I do not believe that the combined procedure should be used routinely in all cases. There may be added risk. We have used it in approximately half the patients being treated for tuberculosis with resection in which we felt that ultimately they would need some reduction in thoracic volume. We have not considered it wise to do a simultaneous thoracoplasty if the operation has been a prolonged one or if the general condition of the patient at the conclusion of the resection would make it seem that this added procedure might increase the risk.

The second point is that if one is attracted by the single stage procedure, I think it is well to maintain the integrity of the chest. It is possible to retailor the chest, maintain rigidity and prevent danger of paradoxic chest-wall movement.

(Slide.) The first step in the method we employ is to divide ribs two, three, four, and five anteriorly from within the chest.

(Slide.) The second step divides these ribs posteriorly and separates the periosteum from the under surface of the first rib.

(Slide.) The third step removes appropriate posterior segments of the second, third, fourth and fifth ribs.

(Slide.) In the final step, the liberated and shortened plate of remaining segments of ribs are swung downward and inward. They are securely fastened to posterior rib stumps. The second rib is usually fastened to the fourth stump, the third to the fifth, etc.

A roentgenograph shows the degree of chest-wall shift obtained by this type of modified thoracoplasty.

The fact that the resection and retailoring can be done in one stage effects great saving in comfort and hospital expense. We have lost only one patient, a diabetic, in whom the combined operation was performed. It was difficult to tell whether or not the added procedure contributed to the outcome. I would, however, like to issue a warning to the effect that if one contemplates using the combined procedure, the cases should be carefully selected.

DR. W. D. KELLEY, Norwich, Conn.—It is encouraging to know that there is still an interest in the surgical treatment of tuberculosis. In spite of the advent and rebirth of such a panacea as BCG we still have a problem. As you know, the tuberculosis death rate throughout the country is something like forty per one hundred thousand population, and even in the small state of Connecticut and other places where we think that tuberculosis has a fairly well-organized program, the death rate is still about thirty per one hundred thousand. So we still have a problem in treatment and I think we should emphasize surgical treatment of this disease. It is interesting to note also that there is such a wide variety in plans of treatment; in fact, it is almost astounding that there should be so many different types of surgical treatment for practically identical types of disease. I wonder if this is not the right time to question whether or not we should not try to come to some standardization of surgical treatment.

As a matter of completeness, I would like to mention our statistics in one surgical unit in Connecticut in relation to resections for tuberculosis. We have a series now of eighty-two cases of resections, including pneumonectomies, lobectomies, and segmentals. There are thirty-one cases of lobectomy, twenty-nine cases of pneumonectomy in this group. In connection with this I would like to say that we have tried the combined operation in three cases; one a lobectomy and two a pneumonectomy, and we found in two of the three cases that there was a considerable increase in morbidity and for that reason we have not continued with the combined operation of thoracoplasty and pneumonectomy.

DR. LAURENCE MISCALL, New York.—In our experience at Triboro Hospital we have not combined resection therapy with thoracoplasty. If we intend to use thoracoplasty it is completed usually as a primary procedure, after which resection has been carried out at a later date. Yet, in certain cases, we have found combined procedure advisable. In these we tailored the thorax by a method which the following slides illustrate. Resection has been combined with mobilization of the apical pleura, which has been turned down over the lung and sutured to the lower margin of the line of incision. This has created an extrapleural space.

(Slide.) On this first plate taken immediately after operation the dots outline the air-filled space above the right middle and lower lobes after removal of the right upper lobe.

(Slide.) This second slide shows that effusion into this space has occurred rapidly. It is clearly demonstrated by the small fluid level at the top of the space.

(Slide.) This next plate taken eight days after operation shows that the complete filling of the space by fluid has compressed the lung and helped to rapidly obliterate the pleural space by bringing it into contact with the lung.

(Slide.) This plate taken five days later shows the ease with which pulmonary expansion can be regulated by aspiration of fluid from the extrapleural collection.

(Slide.) In this lateral view one can see that the right lower and middle lobes have selectively expanded; that the pleural tent parallels the margin of the re-expanded lobe and that the fluid above has decreased.

(Slide.) This plate indicates the ability of collections to persist and organize. At this time, seven months after operation, the pleural tent is equivalent to the four- or five-

rib thoracoplasty. The chest wall has not been disturbed except for the excision of one rib. He was always able to raise secretions well after operation. He has maintained a straight spine and has been quite comfortable. It is possible that these factors have better preserved respiratory function than that observed with similar collapse from thoracoplasty.

(Slide.) This is a plate taken on Mar. 19, 1948, ten days after resection of a left upper lobe for tuberculosis. The large extrapleural hemopneumothorax which can be clearly seen was aspirated on three occasions.

(Slide.) On this plate of Jan. 5, 1949, ten months after operation, one can see the left lower lobe has re-expanded to the level of the fifth rib. Note that the spine has remained absolutely straight and this corresponds to a thoracoplasty of similar degree.

(Slide.) Here is a plate on another patient who had a left upper lobectomy for a tuberculous cavity seen well on the plate on the right.

(Slide.) I am sure, following the report of Dr. Chamberlain, that segmental resection would be preferred now. This (slide) lobectomy, however, was combined with a pleural tent. The effusion into the extrapleural space was aspirated carefully to control expansion. The plate on the right three years later illustrates the definite restriction of overexpansion of the remaining lower lobe.

Our experience with the pleural tent leads us to believe that it is definitely superior to thoracoplasty when one wishes to tailor the thorax at the same time when resection is completed.

DR. LEO ELOESSER, San Francisco.—Pardon me if I take a few words to call attention to something that perhaps you all know. I did not gather from the speakers exactly how they did the thoracoplasty. But through all these very large chest incisions it is quite easy to remove the desired amount of ribs, working from the inside of the pleural cavity, either transpleurally or, if the occasion dictates, subpleurally by pushing the pleura aside.

DR. JOHN M. CHAMBERLAIN, New York.—I want to take a minute to add a word of caution about the use of this combined procedure. On Dr. Berry's service at Bellevue and the other services with which I am associated, we have used the combined procedure in sixty patients. I am sure Dr. Conklin will quickly and readily admit that the postoperative course of these patients is a little more hazardous, and that perhaps the morbidity is increased, because of the paradoxical chest, as Dr. Overholt has pointed out. One other point: In doing these operations it is frequently necessary to go into the extrapleural plane in order to mobilize the lobe. In such cases, when one follows the resection with a thoracoplasty, there are only ribbons of periosteum and intercostal muscle to fall in and obliterate this space. This defect allows the pleural cavity to be in communication with the subscapular collection of fluid and one must therefore deal with a larger hemothorax postoperatively. As a result, I believe the management of these cases requires a great deal more attention. For these reasons, we now enter the pleural cavity through the fourth rib instead of the fifth and then take short segments of ribs three and two. In this way we are able to reduce to a minimum the paradoxical motion. We then mobilize the apex of the lung by incising the periosteum beneath the first rib, just as Dr. Samson does.

DR. CONKLIN (closing).—I thank the numerous discussors and hope that at any future appearance before this Association I may have Dr. Samson's broad shoulders to lean upon. Dr. Dailey mentioned the use of thoracoplasty in conjunction with lower lobe resection. We have thought that the diaphragm does elevate sufficiently to fill the space, and have thought that performing thoracoplasty in these cases displaces the upper and middle lobes in such a manner that it may kink the bronchus or otherwise affect efficiency. The use of a plastic sponge in lobectomy does not seem to me a practicable solution, and certainly any foreign body does not help with the hazards of empyema and bronchopleural fistula.

We have used this procedure, of course, in carefully selected nontuberculous cases, suppurative disease and neoplastic disease. So far as aspiration of fluid is concerned follow-

ing resection and thoracoplasty, as mentioned by Dr. Lester, this is done in our cases according to indications, such as displacement of the mediastinum, and so on. From the paper of Drs. Iverson and Skinner I understand that they always drain the pleural cavity following pneumonectomy and thoracoplasty, and I think in these cases the use of drainage following pneumonectomy is better justified than when no thoracoplasty is performed. Drainage will promote obliteration of the pleural space and there will not be excessive mediastinal displacement as a result of drainage.

We do not use the combined procedure routinely. In other words, as Dr. Overholt mentioned, if the patient's condition does not seem entirely satisfactory when the resection is completed, a contemplated thoracoplasty should be deferred. However, I would like to point out that, particularly with the type of technique we are using, it prolongs the operation very little. Ordinarily we resect one, and very frequently two, of the ribs to be resected before entering the pleural cavity, and that leaves only the uppermost two ribs to be resected at the end of the procedure, and this can be accomplished very rapidly. Dr. Samson carefully timed his cases and found that thoracoplasty added an average of only sixteen minutes to the entire combined procedure and I feel that with a more limited type of thoracoplasty, such as we perform, it averages even less.

Dr. Eloesser asked about the approach to the ribs, whether from the inside or outside. We have on occasion used an intrapleural approach to the ribs and have found it advantageous at times to divide the costal cartilage of the first or second rib from within the pleural cavity with a scalpel. However, we prefer to use the extrapleural approach, dividing subscapular muscles, feeling that in this way the periosteum will drop down against the mediastinum and that the benefit of the thoracoplasty will be promptly achieved.

REVISION THORACOPLASTY

A Review of Twenty-Seven Cases

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THE literature on revision thoracoplasty is somewhat confusing. In 1936, Kinsella[1] advised extraperiosteal gauze packing with revision except in those patients with small cavities who had inadequate first operations. By use of packing, he was able to close eleven of thirteen cavities. Without packing, he was successful in twelve of twenty-three cases. Alexander[2] recommended revision for unsuccessful, inadequately performed thoracoplasties. He felt that the operation was not indicated after a thoracoplasty in which the transverse processes and adequate lengths and number of ribs had been resected. Revision in his hands was successful in twelve of a total of fifteen thoracoplasty failures. Welles,[3] being of the opinion that the real cause of thoracoplasty failure lay in the lesion within the lung, did not recommend revision. He attempted to close the cavities in six thoracoplasty failures by resecting regenerated ribs and transverse processes, and was unsuccessful in all. Weinstein[4] recommended that revision include resection of ribs over the cavity, shortening of adjacent transverse processes, and mobilization of the lung from the vertebral bodies. By this method he was able to convert the sputum of 54.6 per cent of twenty-two patients whose first thoracoplasties had been adequate. Judd[5] recommended plication of the lung on itself to close cavities under thoracoplasties which had been adequate. This method was successful in converting the sputum of 4.35 per cent of twenty-three cases. Hochberg, Fink, and Denize,[6] after reviewing a series of eighty-nine cases of revision thoracoplasty, concluded that revision was most successful in patients whose first thoracoplasty had been inadequate. They were able to convert the sputum of about one-half of the latter group as compared to about one-fourth of their total group.

The twenty-seven cases of revision thoracoplasty presented in this article were consecutively operated upon at Uncas-on-Thames between July, 1946, and January, 1951, during which time 278 cases of thoracoplasty of all types were performed. There were one operative mortality (3.7 per cent) and two late mortalities (7.4 per cent). Two patients received inadequate revisions without resection of adequate lengths of transverse processes, and both failed to develop a negative sputum. Twenty-four patients had what were considered adequate revisions.

In Table I are summarized the results of revision according to accepted criteria for judging adequacy of the first thoracoplasty. Thoracoplasties were considered adequate if the first two ribs had been completely or almost com-

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TABLE I. FOLLOW-UP ON TWENTY-FOUR CASES OF SATISFACTORY REVISIONS

FIRST THORACOPLASTY	NUMBER	SPUTUM CONVERTED TO NEGATIVE	CAVITY CLOSED		CONTRALATERAL CAVITY PRESENT
			BY LAMINAGRAM	BY PLAIN FILM	
I. Unsatisfactory Operation	18	10	6	6	3
A. Inadequate Transverse Processes	9*	6*	4*	5	3
B. Inadequate Transverse Processes and Inadequate Number of Ribs	5	4	2	1	0
C. Inadequate Transverse Processes and Delay Between Stages	1	0	0	0	0
D. Inadequate Transverse Processes, Delay Between Stages and Inadequate Number of Ribs	1†	1	1	0	0
E. Inadequate Number of Ribs	2	0	0	1	0
F. Inadequate Lengths of Ribs	0	0	0	0	0
II. Satisfactory Operations	6	3	2	1	1

*According to death certificate, one of these patients died of "tuberculosis and pneumonia," about two years after revision. Last recorded sputum, one year after revision, was negative. Last available roentgenogram showed no cavity one and one-half years after revision.

†One of these patients died about two and one-half years after revision from carcinoma of the lip. Roentgenogram before revision did not reveal definite cavity.

pletely resected, if the transverse processes had been removed flush with the laminas, if sufficient lengths and numbers of ribs had been resected to collapse the lung well below the cavitary disease, and if a delay of more than three to four weeks had not occurred between stages. A revision operation was considered adequate if it corrected the defects in the first operation. Anterior thoracoplasties were performed according to the method of Haight[7] in all but three of the twenty-four patients summarized in the table.

Reference to Table I will reveal that roughly one-half of the patients who had satisfactory primary operations benefited by revision. In contrast, about two-thirds of the group who had unsatisfactory primary operations benefited

TABLE II. RESULTS OF REVISION ACCORDING TO ROENTGENOGRAM APPEARANCE OF DISEASE BEFORE FIRST THORACOPLASTY

X-RAY APPEARANCE	NUMBER CASES	NUMBER CAVITY CLOSED	NUMBER SPUTUM CONVERTED NEGATIVE	NUMBER WITH CONTRALATERAL CAVITY PRESENT
Giant Cavity	5†	4	4	1
Dense Disease	3*	3*	2*	1
Giant Cavity and Dense Disease	1	0	0	0
Small Thin-Walled Cavity with Infiltration of Slight Density	10	6	5	0

*According to death certificate, one of these patients died of "tuberculosis and pneumonia," about two years after revision. Last recorded sputum, one year after revision, was negative. Last available roentgenogram showed no cavity one and one-half years after revision.

†One of these patients died about two and one-half years after revision from carcinoma of the lip. Roentgenogram before revision did not reveal definite cavity.

by revision. If the group with inadequate removal of transverse processes at primary operation is studied, it will be seen that from three-fourths to four-fifths of these benefited by revision.

Table II summarizes the results of adequate revision according to the roentgenogram appearance of disease prior to the first thoracoplasty. The preoperative roentgenograms were available for review in nineteen cases. In each instance, cavitary disease was apparently localized to the upper lobe. It will be

Fig. 1.

Fig. 2.

Fig. 1.—Chest roentgenogram of typical case in which transverse processes had not been resected at time of original thoracoplasty.

Fig. 2.—Roentgenogram of same patient following revision thoracoplasty. Appropriate transverse processes and regenerated ribs have been removed.

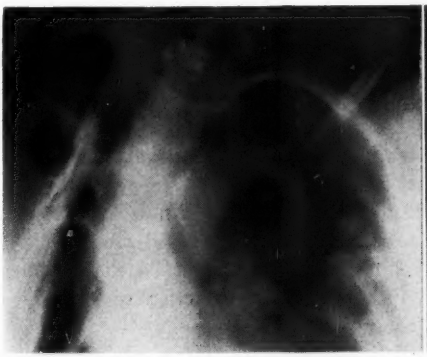

Fig. 3.

Fig. 4.

Fig. 3.—Laminagram of same patient just before revision thoracoplasty. Cavity clearly visible just anterior to transverse processes.

Fig. 4.—Laminagram following revision. Arrow points to region where cavity had been clearly visible but is indefinite. Case is still classified as unsatisfactory result even though sputum is now negative.

noted that there was no significant difference in the response of the categories listed to secondary collapse. One might, therefore, conclude from a study of the two tables that mechanical factors are of more importance than pulmonary pathology (as seen by roentgenogram) in determining the results of thoracoplasty.

Streptomycin therapy was employed in conjunction with revision in four patients, only two of whose operations were adequate. The latter two patients were the only ones in this group to develop negative sputum, which would seem to substantiate the opinion that streptomycin is not a substitute for satisfactory collapse.

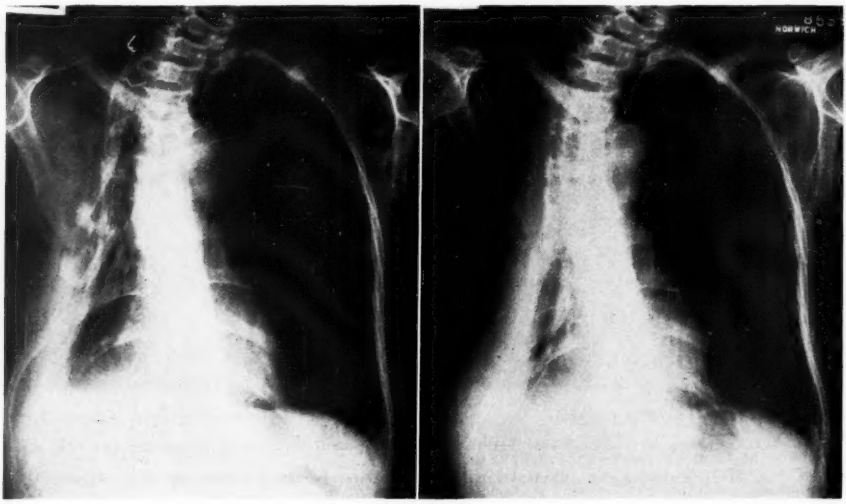

Fig. 5. Fig. 6.

Fig. 5.—Chest roentgenogram showing inadequate removal of transverse processes and anterior rib ends. Diseased lung not satisfactorily collapsed.

Fig. 6.—Roentgenogram of same patient following anterior and posterior revision thoracoplasty showing satisfactory collapse.

Ventilatory function studies were performed on only two patients prior to and following secondary operations. In one instance, the removal of five regenerated ribs, a portion of one additional rib, and an anterior stage diminished the maximum breathing capacity from 92 to 75 liters per minute. In the other case, with removal of eight transverse processes and regenerated ribs and an anterior stage, the maximum breathing capacity changed from 64 to 58 liters per minute. In general, it can be said that respiratory function was not impaired to any great extent by revision thoracoplasty.

It was formerly our custom to resect all or most of the regenerated ribs shortly before or at the time of thoracotomy for pulmonary resection. Four of the patients included in this report had revision and thoracotomy without resection because of technical difficulties. In each case, the lung was freed to a variable degree. Two patients, who had technically adequate revision operations,

have negative sputum and no evidence of cavity. The other two had technically inadequate revisions, and showed persistent cavity and positive sputum. At least in this small group, partial pneumonolysis did not appear to be beneficial.

SUMMARY AND CONCLUSIONS

1. Twenty-seven cases of revision thoracoplasty are reviewed. There were one operative and two late deaths.

2. Revision operation is most successful following inadequate thoracoplasty in which the presence of transverse processes seems to be a significant factor interfering with adequate collapse.

3. The type of disease as noted by roentgenogram in this series did not appear to be a determining factor in the success of revision thoracoplasty.

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LIPOSARCOMA OF THE MEDIASTINUM

Report of a Case With Associated Lipomas of the Mediastinum and Subcutaneous Tissues

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THE literature contains no record of a patient who exhibited the simultaneous presence of a lipoma and a liposarcoma of the mediastinum. This apparently unique association justifies the reporting of a single case.

Liposarcoma is a rare tumor.[1-5] The most common sites of origin are the fascial planes of the thighs and the retroperitoneal tissues. Lipomas, on the other hand, are among the most frequently encountered of all neoplasms. Although seen in many locations, they usually occur in the subcutaneous tissues. The mediastinum is a rare site for either of these tumors.[1, 2, 6-11] The number of mediastinal lipomas reported in the literature comprises a very small group. Less than fifty have been recorded in all intrathoracic locations.[11] Many of these were lesions of the dumb-bell type with a portion of the tumor situated in the neck or chest wall and connected with the intrathoracic component by a stalk or pedicle. Lipomas confined solely to the mediastinum are unusual. The rarity of mediastinal liposarcomas is attested by the fact that a search of the literature reveals only five solitary tumors of that type located in the mediastinum.[2, 6, 12-14] Five cases of multiple liposarcomas have been reported,[15-19] and in at least two of these the mediastinal organs or structures as well as other more common sites were involved.[15, 19]

Benign lipoma and its malignant counterpart, liposarcoma, are very rarely found in combination. Indeed, we have been able to find in the literature only three previously recorded instances of such an association, namely, the case reported by Farbman[20] and the two cases recorded by Starkloff, Saxton, and Johnson.[21]

CASE REPORT

The patient, a 55-year-old Naval officer on active duty, was admitted to the U. S. Naval Hospital, St. Albans, L. I., N. Y., on Nov. 27, 1950, because of the discovery of a large, right superior mediastinal mass by routine chest roentgenogram taken at the time of his annual physical examination. He voiced no complaints except for a mild "cigarette cough" which had been present for many years. During recent months the cough had been harsh, dry, and somewhat more annoying than previously. There was slight huskiness of the voice. The patient attributed both the increased cough and mild hoarseness

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to a strenuous program of public speaking which he had recently been called upon to undertake in connection with his official duties. In the past few weeks he had noticed a tendency to tire somewhat more easily than formerly. Although still able to participate in sports, such as golf and tennis, he had observed increasing shortness of breath after vigorous exercise. He had no chest pain, expectoration, or weight loss. His past medical history revealed no relevant facts. In 1941 he was hospitalized for a few days for acute cystitis. Five years prior to admission he had been discovered on routine electrocardiogram to have a right bundle branch block. This condition persisted but had never given rise to symptoms, and apparently was of no serious clinical significance. There were no facts in his family history pertinent to his present illness.

Complete physical examination showed few noteworthy findings. He was observed to have an intermittent, harsh dry cough. The voice was slightly husky. Rather prominent spider hemangiomata were present over the upper sternal area and on the right upper chest anteriorly. The patient's temperature, pulse, and respiratory rates were normal.

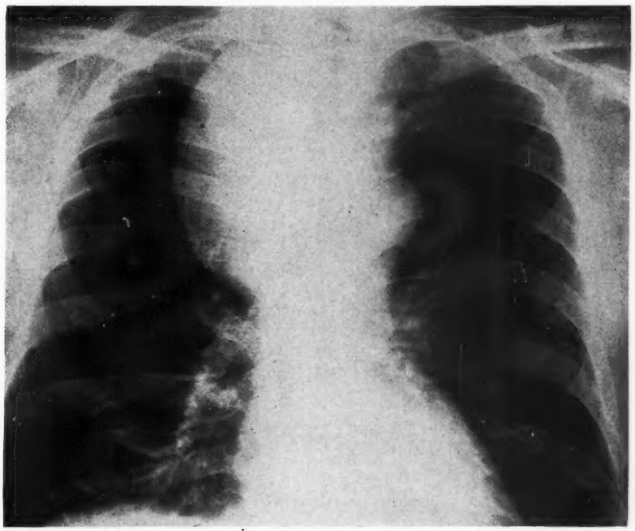

Fig. 1.—Posteroanterior chest roentgenogram taken just prior to admission showing the large superior mediastinal tumor projecting into the right hemithorax.

His blood pressure was 140/90, and equal in the two arms. There were no abnormal physical signs noted on examination of the heart and lungs. Abdominal examination was essentially negative except for a somewhat irregularly shaped mass approximately 8 by 4 by 3 cm. in size, which could be seen and felt beneath the skin in the left lower abdominal quadrant. On palpation this mass appeared to be lobulated. It was not tender and was freely movable, being firmly attached to neither the overlying skin nor the underlying tissues. The physical findings were entirely consistent with those commonly exhibited by a lipoma. The extremities were normal. There was no peripheral lymphadenopathy. Neurological examination was negative. Indirect laryngoscopy showed normal appearing vocal cords whose motion was not impaired.

Routine laboratory studies, including liver and renal function tests, were within the limits of normal. The Kahn test was negative. Posteroanterior (Fig. 1) stereoscopic and right lateral (Fig. 2) chest roentgenograms showed an ovoid mass of homogeneous density, about 14 by 8.5 by 7 cm. in size, which projected to the right from the superior mediastinum. The mass extended from the thoracic inlet to the level of the right hilum.

Stereoscopically and in the lateral projection it was seen to be situated in the upper posterior and mid-mediastinal areas. The tumor was perfectly regular in outline and very sharply demarcated. Its density was perhaps slightly less than one might anticipate from a mass its size. The mediastinum was not displaced, and the lung fields were clear in all areas other than that obscured by the projecting mediastinal mass. A photoroentgenogram made one year previously was available for comparison (Fig. 3). It showed, in retrospect, a clearly visible right paratracheal superior mediastinal tumor which was overlooked when the miniature film was originally read. In the interim of approximately one year the mass had increased at least tenfold in size. No pulsations of the tumor were detected on fluoroscopy, and it was observed that the mass did not move with the lung on respiration.

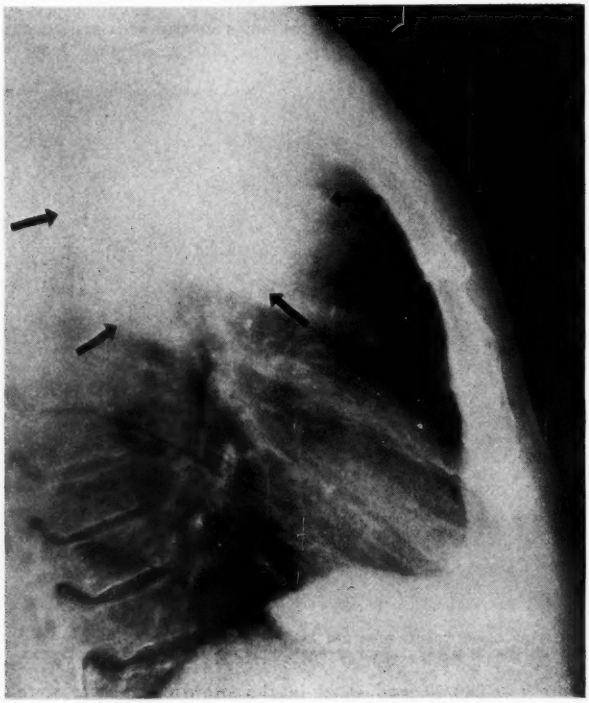

Fig. 2.—Right lateral chest roentgenogram taken a few days prior to operation which shows the central and posterior location of the tumor.

Angiocardiography (Fig. 4) showed that the lesion was definitely extrapulmonary in location. The vascular pattern was normal in the right lung. This procedure not only proved that the mass was not an aneurysm or other vascular lesion, but also showed that there was no serious compression of the great vessels in the mediastinum. Bronchoscopy showed no mucosal lesion in the tracheo-bronchial tree. However, there was marked evidence of compression of the lower trachea and right main stem bronchus, apparently caused by an extrinsic mass on the right. The right lateral wall of the lower half of the trachea was displaced medially. The main carina was blunted and foreshortened in the anteroposterior diameter. The right main stem bronchus was reduced approximately 50 per cent in caliber, and both this bronchus and the lower half of the trachea showed considerable fixation. Although there was definite diminution of the normal mobility of these struc-

tures, fixation was not of the rigid type. The mucosa of the distal trachea and right main stem bronchus was thrown into longitudinal folds or furrows, as if the structures were being squeezed from without. A good view could not be had of the right upper lobe orifice due to the reduction in mobility of the trachea and right main stem bronchus. However, as seen tangentially, it was noted that the upper lobe bronchial lumen was also markedly reduced. The right lower bronchial tree and the entire left side were normal in all respects. The right upper lobe bronchus was lavaged and the aspirate collected for Papanicolaou smears, which were reported as suspicious for malignant cells, Class III. Several subsequent sputum specimens examined by the same technique were negative for malignant cells.

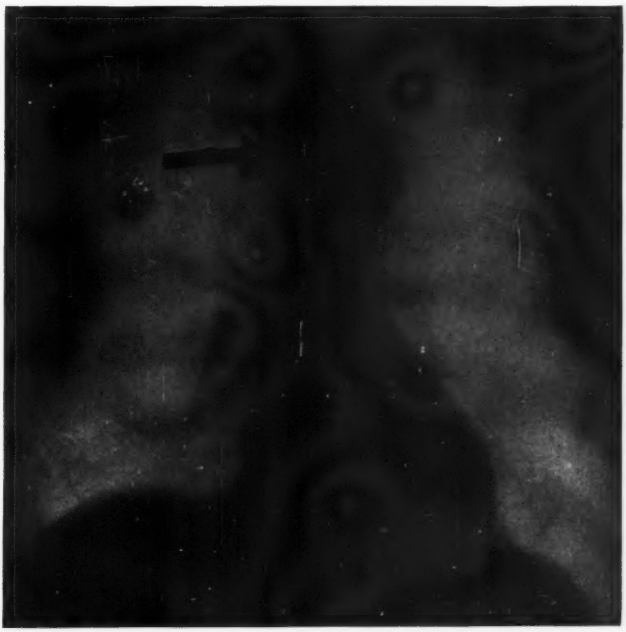

Fig. 3.—Enlargement of a 35 mm. photoroentgenogram made one year prior to admission. Although overlooked when the miniature film was read, the mass was clearly visible at that time.

The subcutaneous mass was removed from the left lower abdominal quadrant on Nov. 27, 1950. Grossly it appeared to be a typical lipoma. The pathologic diagnosis was "lipoma."

Right posterolateral thoracotomy was performed on Dec. 2, 1950. The right fifth rib was resected and the pleural cavity entered by an incision in the bed of the resected rib. A free pleural space was encountered except for a small area over the tumor mass laterally to which the mediastinal surface of the right upper lobe was lightly adherent by fine, easily separated cobweb adhesions. The right lung was normal on inspection and palpation. Examination of the right superior mediastinum established the presence of *two* tumor masses. The larger of these, the size of a large grapefruit, was confined to the mediastinum and completely covered with pleura on its presenting surface. It extended principally into the right chest but, as was demonstrated during its removal, also projected slightly into the left pleural space. In addition, it was found to extend through the right superior thoracic aperture into the lower cervical region. The inferior margin

of the larger mass rested on the smaller tumor to which it was somewhat adherent. The smaller mass in turn abutted inferiorly on the lung root and lay in the crotch between the superior vena cava and the azygos vein. The azygos vein crossed the lower pole of the smaller lesion and was considerably compressed by it. The posteromedial aspect of the smaller neoplasm lay along the lateral tracheal wall and inferiorly nestled in the angle between it and the superior surface of the right main stem bronchus. Viewed from the side, the masses were seen to occupy a central and posterior position in the superior mediastinum, but they did not extend into the costovertebral gutter. Both the right phrenic and vagus nerves coursed in their usual relationship to each other over the surfaces of the masses and were drawn as tight as bowstrings as a result of lateral displacement by the larger tumor. The pleura over the tumors was split in the vertical direction,

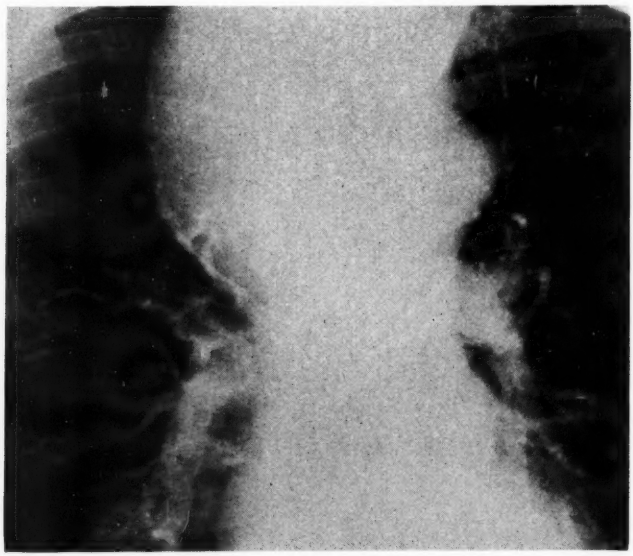

Fig. 4.—Angiocardiogram made shortly before operation. This demonstrated that the lesion was not an aneurysm and showed a normal vascular pattern in the right lung.

and the masses were found to be well encapsulated. An excellent line of cleavage was easily established outside the tumor capsules, and they were readily freed by blunt finger dissection. Each was enucleated intact without difficulty. During the course of the dissection the larger mass, somewhat lobulated in contour, was found to extend across the midline anterior to the trachea and to project slightly into the left chest. There was also a prolongation which traversed the superior pulmonary sulcus and extended for a short distance into the root of the neck on the right. The smaller mass had no identifiable vascular pedicle. The larger tumor was completely freed except for one small area which was seen to contain a slender vascular pedicle no larger than one-half the diameter of a lead pencil. After the pedicle had been dissected out for a suitable distance it was ligated and severed 2 or 3 cm. distal to the mass. When the two tumors had been removed careful examination of the entire right mediastinum showed no residual tumor masses. The chest was closed in the usual manner.

The pathologic report was as follows:

Macroscopic: The specimen consisted of a grayish-white encapsulated tumor measuring 15 by 11 by 6 cm., and a separate encapsulated tumor measuring 5 by 4 by 1.5 cm. The

larger tumor weighed 473 Gm. (Figs. 5 and 6), and the smaller mass 13 Gm. (Fig. 7). The outer surface of both was smooth and glistening, with fibrous tags attached. On section the larger tumor mass (Fig. 6) varied from pale gray to light yellow, with a central portion that was quite firm and rubbery in consistency, surrounded by soft spongy tissue. The smaller tumor (Fig. 7) was pale yellow in color, and had the consistency of adipose tissue.

Microscopic: Sections of the larger tumor mass showed a malignant neoplasm composed, for the most part, of interlacing bundles and strands of spindle cells with poorly defined, slender filamentous basophilic cytoplasm and oval to spindle-shaped nuclei (Fig. 8).

Fig. 5.—Photograph of the larger mediastinal tumor showing the encapsulated, lobulated surface.

The latter exhibited hyperchromatism and variation in size and shape with occasional large, bizarre forms. In a few areas there were islands of adult fat cells together with less well-differentiated lipoblasts, some of which exhibited bizarre, spider nuclei with vacuolated cytoplasm (Figs. 9 and 10). The tumor presented a loose, edematous appearance in general, with areas of myxomatous degeneration and necrosis. There were foci of secondary inflammation and areas showing capillary proliferation. In some areas, bands of collagenous connective tissue were prominent. Fat stain (Sudan III) demonstrated fat vacuoles not only in the adult fat cells but also in less well-differentiated cells (Fig. 11). Bodian stains show an absence of neurofibrils.

This tumor suggested, in some areas, a fibrosarcoma with myxomatous changes. However, the presence of the adult fat cells and less well-differentiated cells taking the fat stain, and of the large, bizarre cells with spider nuclei was characteristic of a liposarcoma. The sections were reviewed by Stout,[22] who concurred in the diagnosis.

Sections of the smaller tumor mass showed adult fat cells surrounded by a fibrous capsule. Attached to the capsule was a fragment of tumor tissue containing large bizarre

cells surrounded by adult fat cells presenting an appearance similar to that of the larger tumor.

The patient's postoperative course was uncomplicated except for a slight paresis of the right phrenic and recurrent laryngeal nerves, evidenced by impairment of function of the right hemidiaphragm and the right vocal cord. The motion of the right leaf of the diaphragm returned to normal within two weeks. Recovery of the right recurrent nerve occurred more slowly, but at the time of his discharge both cords moved normally and his speaking voice was better than before surgery. The patient was returned to full duty on Jan. 15, 1951, at which time his chest roentgenograms were negative except for some thickening of the right superior mediastinal and apical pleura. He was free of symptoms when discharged.

The patient returned for follow-up examination on March 9, 1951. He remained free of symptoms, his voice was normal, fluoroscopy showed no impairment of the function of his diaphragm, and his chest roentgenograms (Figs. 12 and 13) were essentially negative.

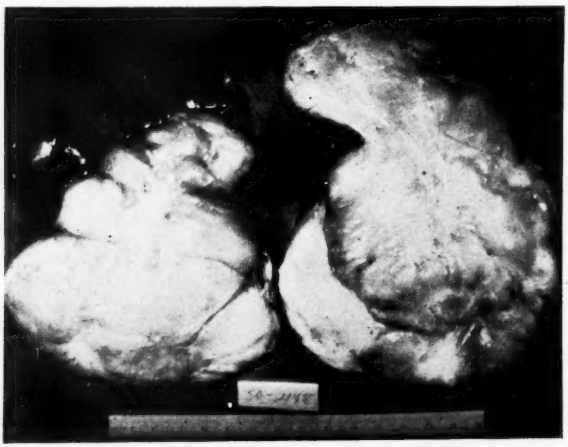

Fig. 6.—The tumor shown in Fig. 5 bisected showing the lobular pattern and variegated appearance.

DISCUSSION

Incidence.—Although Virchow[23] first recognized liposarcoma histologically in 1857, Robertson,[24] in a critical review published in 1916, was able to find only seventeen recorded acceptable cases among fifty-one fatty tumors of unusual type reported to that time. He found eleven additional cases where malignancy was questionable. Moreland and McNamara,[4] in 1942, reported nine instances of liposarcoma among a group of 16,000 patients with tumors, and suggested that the frequency of the lesion may be greater than reports in the literature would indicate. Lingley[25] reported a case in 1939 and stated that it was the seventy-second case to be recorded. In adding a case to the literature in 1949, Cunnick[26] stated that there was a total of 175 previously reported cases. Of these, the great majority primarily involved the fascial planes of the thighs or buttocks, the mesentery and omentum, or the retroperi-

toneal areas. Twenty-one liposarcomas were encountered in the laboratories of pathology and surgical pathology of the Presbyterian Hospital, and only forty-one such cases were accumulated in the laboratory of Surgical Pathology of Columbia University during a thirty-seven year period.[1] Considering the liposarcomas occurring in the mediastinum, such lesions appear to be extremely rare. The cases of Perkins and Bowers,[6] Ackerman and Wheeler,[2] Joske,[12] Lennert,[13] Barbier and Mollard,[14] and the one reported herein constitute the only six cases of solitary liposarcoma confined to the mediastinum of which we could find record. (See Table I.) The case of Narr and Wells[27] is not included, even though the mediastinum and entire left hemithorax were found at autopsy to be involved. Earlier films clearly indicated that the tumor arose as an en-

Fig. 7.—Photograph of the smaller mediastinal tumor (lipoma).

capsulated lesion from the diaphragm or chest wall at the left costo-phrenic angle. None of the forty-one cases reviewed by Stout[1] were mediastinal in location. In reporting a case showing multiple malignant fatty tumors, Ackerman[19] noted that the American literature contained no report of a similar case. He was able to find in the foreign literature, however, reports of four cases believed to represent examples of multiple primary liposarcomas.[15-18] At least two of these cases, including Ackerman's, showed mediastinal involvement.[15, 19] There is some question as to whether all of the lesions described in these reports were primary tumors or metastatic growths.

As to lipomas, mention has been made of the fact that the mediastinum constitutes a most infrequent site. Yater and Lyddane[7] reported a case in 1930, reviewed the literature, and found only eleven previously recorded cases in that

TABLE I. VERIFIED CASES OF LIPOSARCOMA OF THE MEDIASTINUM

AUTHOR	DATE	AGE	SEX	LOCATION	SIZE	METASTASES	DIAGNOSIS	TREATMENT	RESULT
Barbier & Mollard[14]	1926	25	M	Anterior mediastinum. Projected into the right hemithorax	Filled the entire right chest	None	Autopsy specimen	None	Died of mediastinal compression and respiratory embarrassment
Perkins & Bowers[6]	1939	18	F	Posterior mediastinum. Projected into the right hemithorax	Four inches in diameter	None	Surgical specimen	Surgical excision	Excellent P.O. result. Alive and well 3 yr. and 2 mo. later
Ackerman & Wheeler[2]	1942	50	F	Entire mediastinum. Projected into and completely filled left chest	Filled entire left hemithorax	None	Autopsy specimen	None	Died of respiratory embarrassment
Joske[12]	1944	18	M	Posterior mediastinum, at level of seventh rib on the left	4 × 3 × 2 in.	None	Surgical specimen	Surgical excision	Excellent P.O. result. Alive and well 1 year later
Lennert[13]	1949	23	M	Anterior mediastinum. Projected into both the right and the left hemithorax	"Size of man's head" 25 cm. in diameter	Direct invasion of right auricle	Direct aspiration biopsy. Confirmed by postmortem studies	Irradiation 4,600 r. Urethrane Cyren-A Implantation	No response to therapy. Death after 3½ mo. from respiratory insufficiency and cardiac failure
Authors'	1950	55	M	Mid and posterior mediastinum. Projected to right from superior mediastinum	15 × 11 × 6 cm. Weight 475 Gm.	None	Surgical specimen	Surgical excision	Excellent early result. Symptom free and negative chest x-rays 3 mo. P.O.

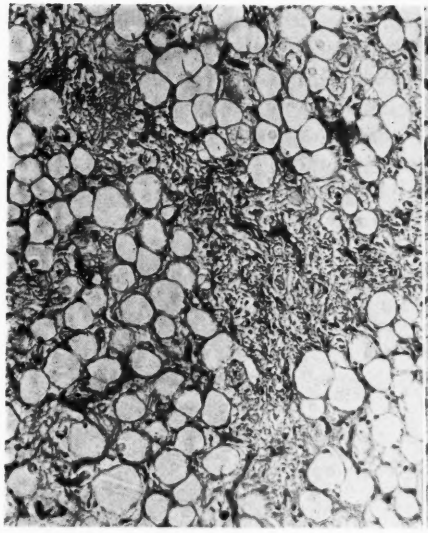

Fig. 8.

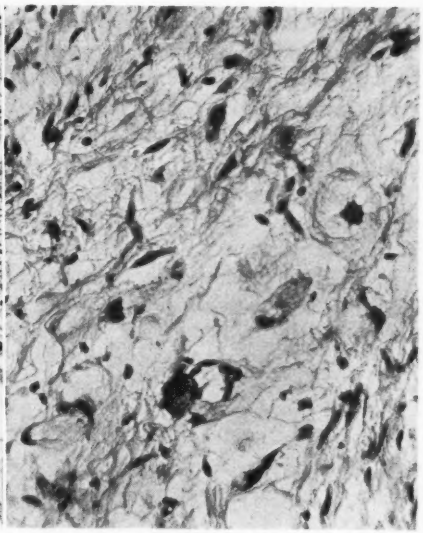

Fig. 9.

Fig. 8.—Section of the tumor showing variation from fully differentiated adult fat cells to anaplastic cellular sarcoma.

Fig. 9.—Area showing immature fat cells with a bizarre giant lipoblast with spider nucleus. There are also several spindle cells with vacuolated cytoplasm.

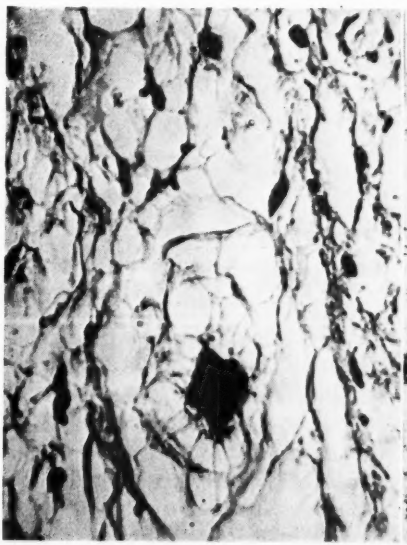

Fig. 10.

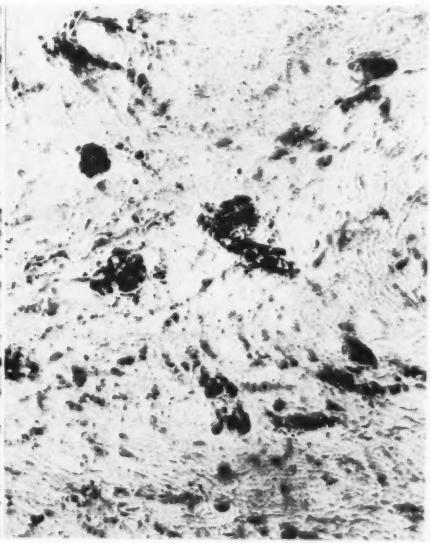

Fig. 11.

Fig. 10.—Detail of Fig. 8 showing giant "spider cell" with bizarre nucleus and vacuolated cytoplasm.

Fig. 11.—Frozen section stained with Sudan IV showing presence of fat in neoplastic cells.

location. Only one of the twelve cases was confined entirely to the mediastinum, the remainder being dumb-bell tumors with cervical or chest wall extensions. The propensity of these masses, when occurring in the mediastinum, to assume an hour-glass configuration with an extrathoracic component has been emphasized by Heuer[8] and Heuer, and Andrus and associates.[28] In 1933 Heuer[8] was able to find a total of twenty-eight cases of thoracic lipomas recorded in the world literature since the first case reported by Fothergill[29] in 1783. Of these, seventeen were confined to the mediastinum, and an additional nine cases of hour-glass tumors involved the mediastinum in part. As late as 1948, Griffin and Guilfoil[11] reported a mediastinal lipoma and stated that the total number recorded from that site still totalled less than fifty. Many of these were dumb-bell tumors and not confined exclusively to the mediastinum.

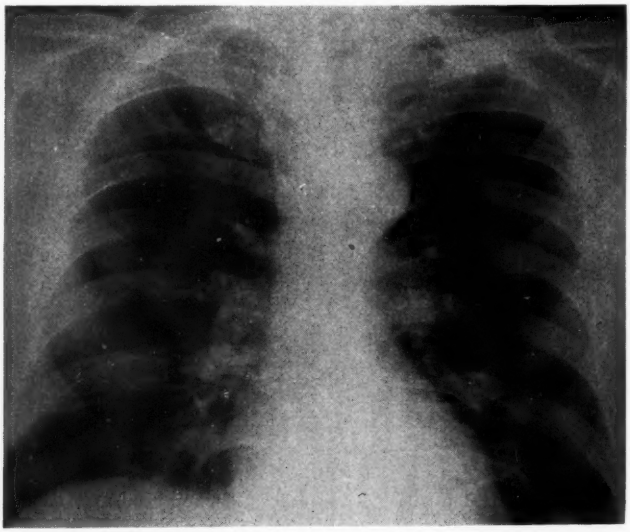

Fig. 12.—Postoperative posteroanterior and right lateral chest roentgenogram, made approximately three months after surgery, showing an essentially normal chest.

Diagnosis.—

It is not the purpose of this paper to discuss in detail the differential diagnosis of mediastinal masses nor to describe the diagnostic investigations that may be indicated in the individual case. Studies similar to those instituted in the case reported herein, including careful roentgen examination employing both roentgenography and fluoroscopy, angiocardiography[30-32] and bronchoscopy will usually be in order. Tomography will occasionally provide additional helpful information, particularly in differentiating solid from cavernous lesions. That technique will also demonstrate the presence of calcium in tumors when it may not be seen in conventional films. Roentgenograms of the esophagus with barium swallow will establish the relationship of that organ to the mass and show evidence of esophageal involvement if present. Roentgenographic

studies will ordinarily offer the most assistance in arriving at a correct diagnosis. The fact that fatty tumors cast an x-ray shadow midway in density between air and water is well known. This observation led to an accurate preoperative diagnosis in the case of liposarcoma reported by Lingley.[25] Selman and Bender[33] and Hunt and Bisgard,[34] among many others, have correctly predicted the presence of a lipoma prior to surgery by that method. Even though preliminary studies fail to establish definitely the nature of the mass in question, the information gained thereby will so clearly define the exact location of

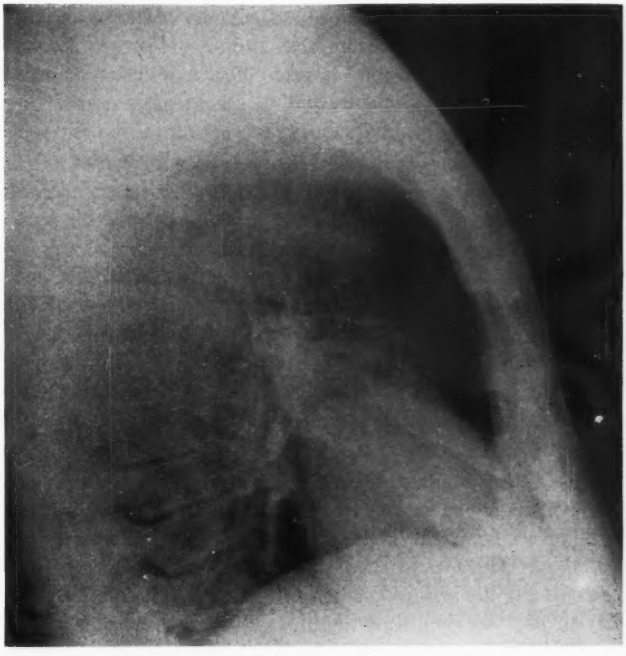

Fig. 13.—Postoperative posteroanterior and right lateral chest roentgenogram, made approximately three months after surgery, showing an essentially normal chest.

the tumor and its relationship to adjacent structures that it will be most helpful to the surgeon. Despite the most painstaking investigation, thoracotomy will usually be mandatory before an accurate histologic diagnosis can be made. The principle that all unilateral circumscribed mediastinal tumors should be subjected to exploration has been widely accepted by those interested in surgery of the thorax. At operation the tumor is removed if possible, and if resection does not prove to be feasible it is biopsied in order to obtain a precise pathologic diagnosis. Knowledge that approximately 25 per cent of these tumors of the mediastinum will prove to be malignant serves to emphasize the necessity for early surgical therapy. The tendency of a significant percentage of lesions which are originally benign to undergo malignant change has been accepted by

many authorities. Even those tumors which remain histologically benign can cause serious illness or even death of the patient as a result of pressure on adjacent vital structures. These facts make it abundantly clear that resection of all mediastinal tumors is indicated when excision is possible. In the final analysis, the definitive diagnosis in mediastinal liposarcomas and lipomas, as in the vast majority of mediastinal tumors, rests upon a careful pathologic examination of the entire specimen after surgical excision.

Pathology.—According to Stout,[1] liposarcomas present a variegated gross appearance. They are large, bulky, sometimes nodular, encapsulated masses ranging in color from pale yellow to orange. Areas of increased vascularity or hemorrhage may cause slight variation of this color. Most are slimy and mucoid and are surrounded by firm, fibrous tissue. Not infrequently areas of normal appearing fat are present. It is unusual to see areas of cystic degeneration. Local multiple nodules are frequent, and often account for recurrences.

Microscopic features are even more varied. Ewing[35] divided liposarcoma into two main types: the myxoliposarcoma, which is vascular, myxoid, and lipoblastic, and the granular cell lipoblastoma composed of cells resembling the foamy lipoblasts of brown fat. Stout[1] divides liposarcomas into four groups: (1) well-differentiated myxoid type, (2) poorly differentiated myxoid type, (3) round-cell or adenoid type, (4) mixed types. In the well-differentiated myxoid type, of which the case herein reported is an example, there are adult fat cells and embryonal stellate or spindle-shaped cells containing droplets of fat, which stain with Sudan III or Scharlack R. This is the less malignant group and it is questionable whether such tumors ever metastasize while they remain in this state of differentiation.

It is of special interest in this case that an encapsulated lipoma was found adjacent to the liposarcoma in the mediastinum. In addition, an encapsulated lipoma was removed from the abdominal wall which histologically showed no malignant change. Since there are several well attested cases of malignant change in pre-existing benign lipomas (Stout,[1] Schiller,[36] Adair and associates[37]) the possibility of such an origin of the mediastinal liposarcoma was entertained in the present case. However, multiple sections of the tumor failed to show definite proof of such origin. Stout[1] states that it is probable that the large majority of malignant lipoblastic tumors are malignant from their beginning. The case reported in this paper is also interesting in the light of the conception of Gideon Wells[38] that adipose tissue should be considered as a specialized organ subject to systemic disorders, similar to the endocrine glands. He noted that fat tissue, behaving as a specialized organ, could be the site of a malignant process. Siegmund,[17] in reporting a case of multiple primary liposarcomas, concluded that it represented "systemic malignant disease of fatty tissue." He compared it with lymphosarcoma and von Recklinghausen's disease. Ackerman[19] reported a similar case and reviewed the four previously described. He concluded that his case as well as the four preceding ones supported the opinion that adipose tissue should be considered as an organ subject to its own diseases. The case recorded in this report might be interpreted as adding further support to that concept.

Treatment.—The number of liposarcomas reported has been too few to enable one to formulate a rational plan of therapy on the basis of experience. Reports on the radiosensitivity of these tumors vary greatly. Ewing[35] stated that many of them show considerable radiosensitivity, and he suggested that radiation therapy be used with surgical excision of the residual tumor if demanded. Geschickter[3] feels that these tumors are radiosensitive, but he does not claim that they are cured by that method. He found ultimate recurrence and metastasis to be the rule. Review of the reported cases leads one to agree with Ackerman and Wheeler[2] that the value of irradiation is questionable, though some tumors have been proved to be definitely radiosensitive.[1, 3] The differing opinions which have been expressed concerning the necessity for radical surgery are probably a reflection of the varied pathologic characteristics which liposarcomas present. Thus Goormatigh and associates[18] believe that the name liposarcoma has a more ominous significance for the surgeon than is warranted by the slow growth of the tumor. Ackerman and Wheeler[2] observe that the degree of malignancy is not considered as high as that of other sarcomas. With reference to liposarcomas of the breast, de Navasquez and Horton[39] have expressed the opinion that radical surgery is not necessary for long survival. On the other hand, Starkloff and associates[21] and Morgan[40] have recommended amputation when the lesion is situated in a location where such a procedure can be considered. McCormick[41] advises preoperative irradiation and radical surgery. Ackerman and Wheeler[2] propose removal with postoperative irradiation if there is doubt as to complete excision. They also suggest that irradiation be tried in inoperable cases. The most rational therapeutic program seems to be that outlined by Stout,[1] who bases his advice on the relative degree of malignancy of the lesion. In the well-differentiated tumors he feels that generous local excision is sufficient, for the worst that may happen in this group is local recurrence. In all other liposarcomas, consisting as they do of more highly malignant tissues, radical surgery is urged. Stout[1] does not feel that irradiation is a form of therapy which should be entirely abandoned, and the circumstances of an individual case may dictate its use. Insofar as mediastinal liposarcomas *per se* are concerned, the deep-seated location of these tumors makes surgical excision even more urgently indicated than in the superficially situated lesions. In attacking these growths surgically the greatest care should be exercised to remove the entire capsule and the tissue immediately adjacent to it in order to assure the most complete possible resection of all malignant elements.[1]

Prognosis.—Patients with liposarcoma must be offered a guarded prognosis. Those with a well-differentiated tumor have a favorable outlook as long as the lesion retains its differentiation.[1, 39, 42] The infiltrative nature of these neoplasms is shown by their ability to recur locally on repeated occasions, sometimes after a long free interval.[1-3, 25, 35, 41-44] Metastases are the rule in the less differentiated types.[1, 2, 3, 25, 41, 44] They may be by way of either the blood or lymph streams and occur most commonly to the liver and lungs. Metastatic lesions may result in death of the patient by invasion of a vital structure or from secondary pressure effects. McCormick[41] has emphasized that one may be

deluded into offering a good prognosis in a case of liposarcoma because of its apparent encapsulation when such an optimistic outlook is not justified in view of the nature of the neoplasm.

SUMMARY

A case of primary liposarcoma of the mediastinum associated with a mediastinal lipoma and a subcutaneous lipoma of the anterior abdominal wall is reported. This appears to be the sixth case of solitary mediastinal liposarcoma to be recorded in the literature. There are only three reported instances of the concomitant occurrence of liposarcoma and lipoma, and there is no record of the simultaneous occurrence of mediastinal liposarcoma and lipoma.

The mediastinal tumors were successfully resected, making this the third recorded mediastinal liposarcoma to be removed surgically. We believe that surgical excision is the treatment of choice.

The literature pertaining to liposarcoma is briefly reviewed.

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A DEVICE FOR PRODUCING REALISTIC PULSATION OF A DEAD HEART

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NEW operative techniques must be worked out as fully as possible on the cadaver and experimental animal before they can be applied to the human being. This is especially true in cardiac surgery where success depends on rapid faultless procedure, and there is no margin for clumsiness or error. The pioneers of heart valve surgery have very properly recorded cases in which death was directly attributable to technical failures.[1, 2]

Experimental operations on animals are invaluable, but not entirely adequate, since very large dogs are difficult to obtain, the anatomy not identical, and cases of stenotic valvular disease never found. Operations on the cadaver allow study of the anatomic approach, but give no information on such vital matters as the control of hemorrhage or the feel and handling of pulsating structures.

To overcome this difficulty, a simple apparatus has been designed which when filled with citrated blood and attached to the dead heart causes that organ to pulsate in a most realistic manner. It can be used in vitro or in situ with a minimum of disturbance to the thoracic viscera, and is easily and rapidly connected. The rate and volume of the pulsations may be altered at will.

The close similarity of the contractions and valve movements thus produced in dead dogs' hearts to those of the living animal has been amply confirmed. The findings on digital palpation in a case of mitral stenosis tallied closely with those found at operation by Brock.[3]

The procedure has so far been used mainly for experimental mitral valvulotomy in the dead human heart.

CONSTRUCTION

The apparatus (Fig. 1) consists essentially of two rubber bulbs of 250 c.c. capacity each, enclosed in an airtight glass fronted box. This latter is connected to a pulsator which alternately compresses and expands the air around the bulbs and thus indirectly their contents.

The bulbs are connected by short wide bore rubber tubes to cannulae tied into the aorta and pulmonary artery, respectively. Manometers are fitted and pressure bottles enable any lost blood to be replaced with the apparatus still in action. For the sake of clarity only one pressure bottle and cannula setup is shown.

METHOD OF SETTING UP THE APPARATUS

The following arrangement has proved suitable for experimental mitral valvulotomy. With a little ingenuity it may be adapted for any cardiac operation.

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The aorta is cut off within 2 in. of its origin, and its valve cusps slit transversely with Mayo scissors to produce complete incompetence. The pulmonary veins are then ligated, and the cannula tied into the aortic stump. The clip *A* is then opened, and the left heart and apparatus slowly filled with blood from the pressure bottle; the ventricle being squeezed all the while to get rid of any surplus air. The clip *A* is then closed, and any remaining air bubbles expelled

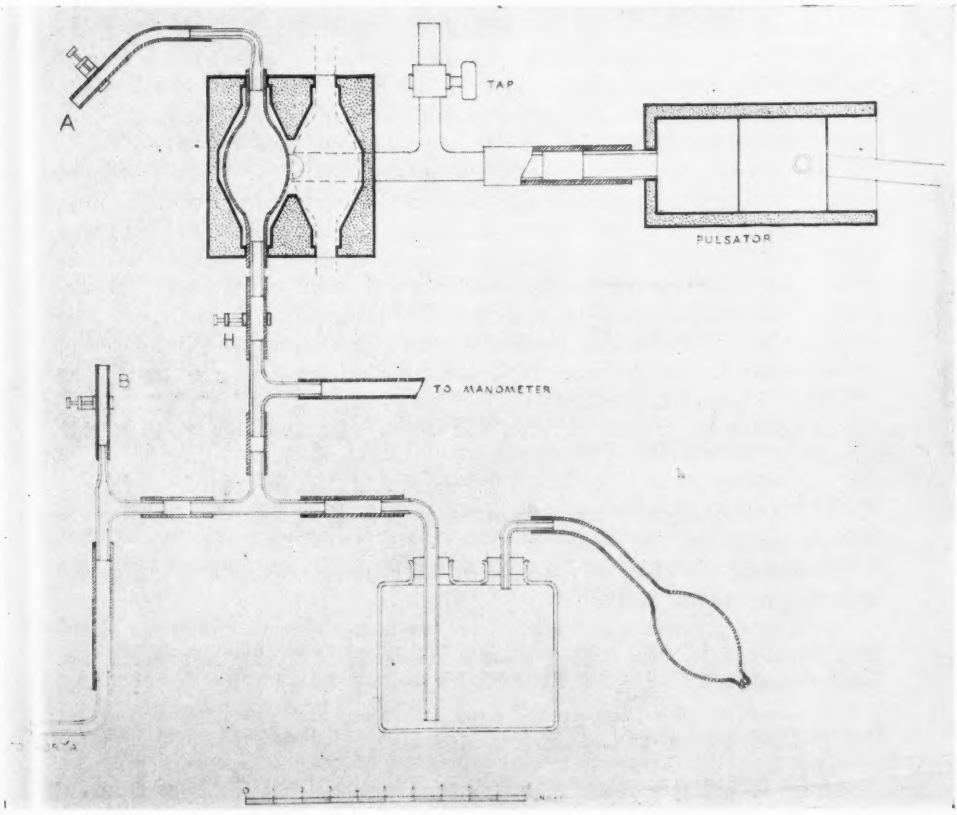

Fig. 1.

through the side tube *B*. It will be found that the auricle slowly fills with blood even though the valves are normally competent. A similar procedure is carried out with the pulmonary artery after the venae cavae have been ligated.

The pulsator is then started and the heart beats in a most realistic manner for as long as may be required. The pressures in either side of the heart can be measured with the manometers, and adjusted as desired by means of the screw clamps *H* and *H'*.

Should operative procedures result in serious "hemorrhage," blood may be replaced in known quantities from the pressure bottles without interfering with the heart in any way.

When operations are carried out on the mitral valve with the heart in situ the aorta may be conveniently reached by resecting the first 3 in. of the right second costal cartilage and rib. An extension downward through the third costal cartilage will bring the pulmonary artery within view. The left chest is thus left virgin for surgical procedures.

DISCUSSION

With every new operation the mortality declines as experience is gained. Anything that will reduce the number of these early disasters and enable the inevitable mistakes to be made on the dead rather than the living is worth while. The artificially pulsating heart may therefore come to have a definite place in the development of new procedures, and in the training of cardiac surgeons. With it intracardiac structures may be examined, and procedures carried out on pathologic hearts under realistic conditions. As in no other way skill may be acquired in cutting rapidly moving stenosed valve rings. Serious mistakes while entering or leaving the heart cavities will result in torrential "hemorrhages" exactly simulating the consequences of mishandling in the living. Also emergencies, e.g., the tearing out of the purse-string suture around the base of the auricular appendage, may be deliberately produced to give practice in dealing with potential disasters.

Cardiac surgery units will find this simple apparatus well worth a trial.

SUMMARY

1. The necessity for the utmost surgical skill in cardiac operations is strongly emphasized.

2. Reasons are given why completely adequate experience cannot be gained on animal or cadaver hearts.

3. A new apparatus is described for producing realistic pulsations of the dead human heart, thus making possible experimental operations under almost natural conditions.

4. A method of setting up the apparatus for mitral valvulotomy is given.

5. Some uses for the apparatus are discussed.

Acknowledgement is made to Prof. R. D. Wright, Professor of Physiology in the University of Melbourne, both for the provision of experimental facilities and for constant help and encouragement.

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A NEW OPERATING CARDIOSCOPE

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THE value of blind commisuriotomy in certain types of mitral stenosis is becoming widely recognized,[1-3] but until the valve orifice can be inspected, and the commisures cut under direct vision, accidents would seem inevitable.[4] Cardioscopes of the traditional lens-in-tube construction have not proved entirely satisfactory. A new instrument has therefore been devised, which, while retaining the contact vision principle, utilizes the unique light transmitting properties of solid perspex (methyl methacrylate). A wide brilliantly illuminated field is obtained through which intracardiac structures can be clearly seen in the living animal.

This cardioscope (Fig. 1) can be made within a few hours in any laboratory workshop. It has the following important advantages over previous types. (1) Simplicity: the entire instrument, apart from the operating knife, is formed from solid perspex of uniform refractive index. (2) The visual field extends to the extreme edge of the instrument without obstruction by light bulb or metal casing. (3) There are no lenses to become misted over or produce aberration. (4) The light source is outside the instrument, it can therefore be really adequate, and if necessary replaced in a few seconds with the instrument still in situ. (5) The tip may be fashioned to any desired plane surface or angle (Fig. 3) without distortion or light loss. (6) Polished perspex is easily sterilized by immersion in cetyl trimethyl ammonium bromide, it does not transmit heat, and its water-repellent surface is ideal for contact with delicate tissues.

CONSTRUCTION

The instrument consists of a perspex body containing the cutting mechanism, with a total weight of 6 oz., and a detachable light holder. The whole can be rapidly taken apart for cleaning.

The body 10½ in. long and 1 in. in diameter is made from solid perspex rod turned down at one end to form a 2½ in. operating shaft ½ in. in diameter, which is bored to carry a 3/32 in. knife and haft. Both ends are very carefully polished to a dead flat transparent surface. The light transmitting arm also of 1 in. diameter rod is cemented to the main body with perspex solution to form a single homogenous unit.

The knife haft passes through the operating shaft and along a groove in the body of the instrument to be attached to a spring loaded plunger. This arrangement insures that the knife is automatically withdrawn into the operating shaft when not in use.

Various types of shaft tip and operating knife that have been used are shown (Figs. 3 and 4). The hooked knife (Fig. 4 *C*) was found especially

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useful in cutting the mitral valve cusps of normal animals; unlike the others, however, it has the disadvantage of not withdrawing completely into the shaft. Blunt headed knives are less liable to cause injury, but, unless double edged, necessitate the cardioscope being turned through 180 degrees to cut both ends of a stenosed mitral orifice.

The source of light, a 24 watt, 12 volt bulb, is carried in a jacketed holder through which water circulates continuously. It is secured to the light transmitting arm by a single screw.

EXPERIMENTAL USE

The cardioscope has been tested mainly on the mitral valves of dogs, being introduced via the left auricular appendage using Brock's purse-string technique.[5] A very satisfactory view of the valve cusps, chordae tendineae, and mitral ring was obtained in every case, and it was possible to cut the valve cusps at any desired point.

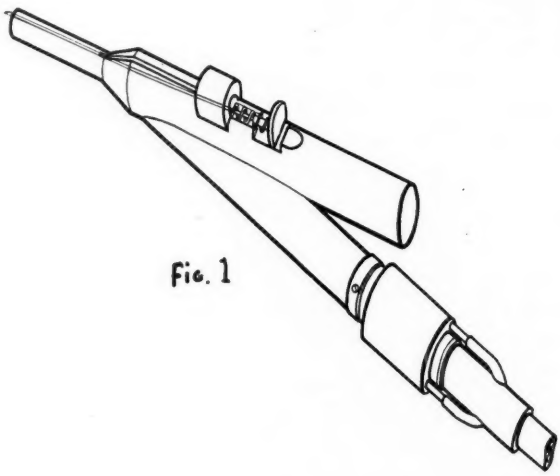


Fig. 1

The instrument was well tolerated within the auricle for upwards of one hour. In one dog, a greyhound, it was passed right through into the ventricle and the papillary muscles inspected without causing undue disturbance. Since the instrument never entirely blocked the mitral orifice there was no violent reaction like that following the insertion of the index finger.[6] Dogs whose posterolateral valve cusps had been cut under direct vision made an uninterrupted recovery.

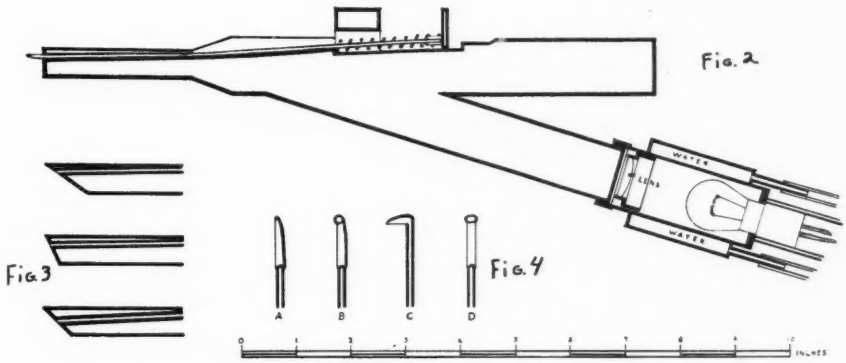
Operations on the blood filled cadaver heart showed that a stenotic valve could be clearly visualized and accurately cut along the commisures as far as the mitral ring.

In the later experiments a cardioscope with an angulated tip was used. This allowed operation to be carried out through a much smaller thoracic incision without any loss of visual acuity.

DISCUSSION

This instrument allows operations on the mitral valve to be carried out under direct vision. It should therefore be especially useful when the valve cusps are grossly distorted or calcified. In these cases blind maneuvers sometimes split the valve at its weakest point, i.e., transversely, instead of along the commisures, with fatal results.[7] As with other endoscopic procedures, skill comes rapidly with practice and it should be possible to cut a stenosed valve at any point desired without risk of damaging the chordae tendineae.

Every extra maneuver inside an enfeebled heart must increase the risk of a fatal arrythmia; with this instrument the valve can be inspected and cut in one operation. It should be possible to deal adequately with a stenosed valve in less than 60 seconds.



The operating shaft being much thinner and more easily introduced than the index finger (diameters as little as one-third inch give a fair field of vision), other uses suggest themselves. For example, a modified form of instrument might be introduced via the innominate artery in cases of aortic stenosis without undue interference with the cerebral blood supply. Further work is proceeding on these problems.

SUMMARY

1. The necessity for an efficient cardioscope is discussed.

2. The advantages of utilizing the unique properties of perspex are enumerated.

3. Constructional details of the new instrument are given.

4. Some experiences with the mitral valves in living dogs and the human cadaver are described.

5. Certain types of stenosis where operations under direct vision seem especially necessary are referred to, and speculations made as to other possible procedures.

Acknowledgement is made to Prof. R. D. Wright, Professor of Physiology in the University of Melbourne, both for the provision of experimental facilities and for constant help and encouragement.

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NOTICE OF ANNUAL MEETING

The American Association for Thoracic Surgery

The Thirty-second Annual Meeting of the American Association for Thoracic Surgery will be held May 8, 9, and 10, 1952, in Dallas, Texas. Headquarters will be at the Hotel Baker. The Adolphus Hotel and the Southland Hotel are near by and will also have suitable accommodations.

Requests for Hotel Reservations: These should be mailed directly to S. Hugh White, Room Reservation Manager, Hotel Baker, Dallas 1, Texas.

Abstracts for Papers: Abstracts for the presentation of papers at the 1952 Meeting must be received for consideration by the Program Committee on or before Jan. 1, 1952. These abstracts should be submitted in *quadruplicate* and addressed to the Secretary of the Association, Dr. Paul C. Samson, 2938 McClure St., Oakland 9, Calif. They should not be sent to the Editor. Abstracts received after Jan. 1, 1952, will not be considered.

Applications for Membership: All correspondence regarding applications for membership, *including* requests for membership applications should be addressed to the Chairman of the Membership Committee, Dr. Edward M. Kent, 1107 Clark Bldg., Pittsburgh 22, Pa. Completed membership applications must reach Dr. Kent on or before Jan. 1, 1952, in order to be acted upon at the annual meeting in Dallas.

PRIMARY LYMPHOMA OF THE LUNG

Review of the Literature, Report of One Case, and Addition of Eight Other Cases

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Sayre, Pa.

PRIMARY lymphoma of the lung is a rare disease. Some case reports are to be found in series of various types of lymphoma, as Sugarbaker and Craver,[1] who found one instance of a primary pulmonary tumor in a series of 196 lymphosarcomas. Others may be found in some of the series of solitary lung tumors, as in Thornton, Adams, and Bloch's[2] report of twenty-three cases of solitary lung tumor, of which one was listed as a lymphoma. Only six reports, however, have been found in the literature which specifically recount individual cases of primary pulmonary lymphoma.

To this group of six individual case reports we would like to add one which we have studied. To add further to the knowledge of the incidence, the behavior, and the therapeutic possibilities in dealing with this tumor, we wrote to fifteen surgeons who have had wide experience with thoracic tumors. Of these, only five reported that they had seen cases of primary lymphoma of the lung. These five surgeons have observed a total of eight such patients, and they have given us some of the information concerning their results in the care of these.

While the number of cases, both in the literature and those gleaned from the reports furnished by these surgeons, is small, certain conclusions may be drawn regarding this rare tumor. The picture which may be drawn from this meager information will probably require amendment as more cases are found through mass radiographic studies. An analysis of the information available of the fifteen cases of which we have knowledge is to be found in Table I.

Our interest in this subject was stimulated by the following case.

CASE REPORT

A 47-year-old housewife was admitted to the Guthrie Clinic Nov. 8, 1949, complaining of a dull aching pain in the epigastrium, present for two months. The pain was aggravated by most foods, especially fatty and leguminous ones. There was neither nausea nor vomiting. She had a 10 pound weight loss in the previous two months. Some relief was experienced with antacid proprietary drugs. The referring physician felt that clinically she had a peptic ulcer.

Systemic and family review were unrevealing. There were absolutely no pulmonary symptoms. The physical examination revealed a moderately obese woman, with all physical signs negative except mild tenderness in the epigastrium. Extensive laboratory studies revealed only a mild microcytic anemia. The study of the gastric acidity by the caffeine method revealed a slight elevation. The blood sedimentation rate was normal. The routine chest film (Fig. 1) showed a discrete, smoothly rounded shadow in the lower lobe of the right lung near the costophrenic angle about 6 cm. in diameter. The remainder of the lung fields were clear, and the mediastinal shadow was normal. The radiologic examination of the stomach revealed a constant defect along the greater curvature of the stomach with a crater superimposed on it.

It appeared most likely that this patient was suffering from a gastric carcinoma with metastasis to the chest. Therefore, gastroscopic study with the operating gastroscope was carried out. This revealed what was believed to be a healing gastric ulcer with a granulating

From the Surgical Service of the Guthrie Clinic.
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TABLE I.

AUTHOR OR SURGEON	AGE	SEX	SITE	SIZE	SYMPTOMS	METASTASES	BRONCHOSCOPY	OPERATION	RESULT
Pekelis[4]	–	–	L.L.L.	"Orange"	No	Yes	No	No	
Spatt & Grayzel[5]	34	F	R.L.L.	17 by 11 cm.	Yes	No	Yes	Lobectomy	alive 14 mo.
Churchill[6]	45	F	R.U.L.	15 by 11 by 7 cm.	No	No	Yes	Lobectomy	well 6 mo.
Maier[3]	50	M	L.U.L.	massive	No	No	Yes	Pneumonectomy	well 19 mo.
Weissman & Christie[7]	52	M	L.U.L.	massive	Yes	No	Yes	Pneumonectomy	well 15 mo.
Anlyan, Livingood & Klassen[8]	63	M	R.L.L.	6 cm.	No	No	Yes	Lobectomy	well 15 mo.
Beck and Reganis	47	F	R.L.L.	6 cm.	No	No	No	Lobectomy	well 15 mo.
Behrend*	59	F	L.L.L.	—	Yes	No	Yes	Pneumonectomy	well 13 mo.
Touroff*	–	–	R.U.L.	5 cm.	–	No	–	Lobectomy	well 30 mo.
Betts & Overholt*	–	M	R.U.L.	massive	–	Yes	–	Inoperable	died 3 mo.
Blades*	–	M	–	massive	–	Yes	Yes†	Inoperable	died 9 mo.
Ochsner & deCamp*	66	M	–	—	–	Yes	–	Autopsy	
	–	M	L.U.L.	—	–	No	–	Lobectomy	died 4 yr.
	50	F	L.U.L.	—	–	No	–	Pneumonectomy	well 9 yr.
	46	M	R.U.L.	—	–	No	–	Pneumonectomy	well 19 mo.

*The cases reported above from the services of Dr. Hehrend, Dr. Arthur Touroff, Drs. Richard Overholt and Reeve Betts, Dr. Brian Blades, and Drs. Alton Ochsner and deCamp, were personal communications to the authors from approximately fifteen clinics polled.

†This is the only bronchoscopic study that yielded a positive biopsy.

base. The remainder of the stomach appeared to be normal. Biopsies were taken through the gastroscope.

The pathologist studied nineteen separate sections of tissue. He found the gastric epithelium to be completely benign with preservation of the normal architecture. The ulcer showed the typical degeneration found in the base of a gastric ulcer with necrosis and some inflammation, but no evidence of malignant cellular activity.

After considerable consultation and discussion between the gastroenterologist, the pathologist, and the surgeon, it was decided that an exploratory thoracotomy was indicated.

Thoracotomy was performed through the bed of the seventh rib. The pleural cavity was found to be entirely free. There was a firm mass palpable in the lower lobe of the right lung. There was no demonstrable enlargement of the hilar lymphatics and the mediastinal lymphatics appeared to be entirely normal. The lower lobe of the lung was resected, in the usual manner.

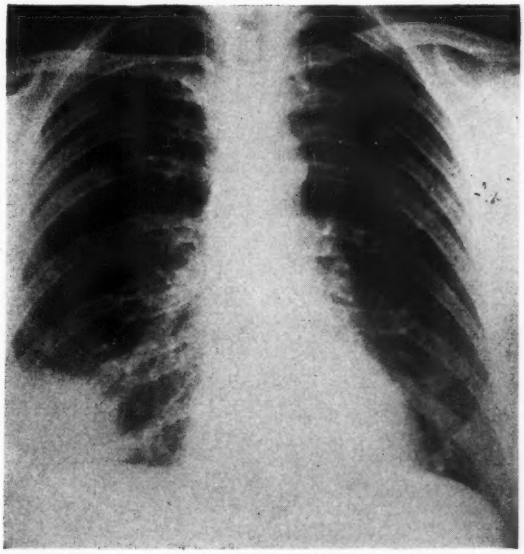

Fig. 1.—Discrete, smoothly rounded shadow in right lower lobe near the costophrenic angle.

The gross description was a mass, roughly globular measuring about 8 cm. in diameter (Fig. 2). Surrounding the mass there was normal lung tissue, containing air. Peripheral to the tumor there was some atelectatic lung tissue. Microscopically (Fig. 3) the lung tissue surrounding the tumor appeared approximately normal. The tumor itself was made up of lymphoid tissue, consisting of small round cells having a complete absence of stroma with exception of some remaining strands of pulmonary tissue. These cells invaded the pleura where the tumor was in contact with it, and extended into the alveoli of the subadjacent lung. There were small groups of cells simulating follicles, but actually circumscribing blood vessels. The diagnosis of lymphosarcoma (Dr. C. H. DeWan) was confirmed in the Armed Forces Institute of Pathology.

During convalescence from the operative procedure, the patient was placed upon an ulcer regimen, and her gastrointestinal symptoms disappeared. Before she was discharged from the hospital, a gastrointestinal roentgenologic study was performed and revealed complete healing of the ulcer. She had been followed on an ambulatory basis with repeated chest films and studies of the stomach and duodenum over a period of fifteen months. She has been in splendid health during this time without any evidences of either pulmonary or gastrointestinal disease.

Discussion.—

The adventitious finding of a pulmonary tumor was the result of the routine study of the chest which is made on all of our patients. The attempt to correlate all findings into one disease entity might well have resulted in abandoning this patient as hopeless, with pulmonary metastasis from a gastric cancer. The reliance placed upon the gastroscopic biopsy certainly was proved warranted.

It is interesting to note that the patient reported by Herbert C. Maier[3] was also examined because of a chronic gastric ulcer. This is, in our opinion, coincidental, but indicates the value of complete examination of every patient. It also emphasizes the value of the exploration in all solitary tumors of the lung.

Fig. 2.—Gross cut section of lymphoma within the lung showing the typical hyaline appearance of lymphosarcoma.

DISCUSSION

In this review there were available for study fifteen cases. Six of these cases are derived from articles in the literature, eight from reports sent to us by surgeons but as yet unpublished, and one from our own service. Only one of these fifteen is an autopsy report, the others all having been studied, diagnosed, and treated during life. In seven we have the clinical background; in these only three had symptoms referable to the tumor. The other four were diagnosed only after the tumor was observed in a routine roentgenogram study of the chest. The three with symptoms all had cough varying from three months to one year. Two of these also had hemoptysis. In one patient there was also extensive weight loss, weakness, and lassitude. This patient had an extensive involvement of the entire upper lobe. Nevertheless, this patient survived a pneumonectomy for at least one year.

The sex incidence showed a moderate preponderance in males. This is typical of both lymphosarcoma and lung cancer of other types. The ages varied

from 34 to 66 years, which also is typical for both lung cancer and for lymphosarcoma.

Cytologic studies of the sputum were made in four cases, but in none was it positive. Bronchoscopy was carried out in six of the fifteen patients. In three it was reported to be normal. In one it revealed suppuration in the affected lobe. In one it showed a narrowing and distortion of the bronchus in the affected area. In only one case was the tumor revealed and a positive biopsy taken. This was, of course, the only patient in whom a preoperative diagnosis was made, or even suspected. Unfortunately it was also not resectable.

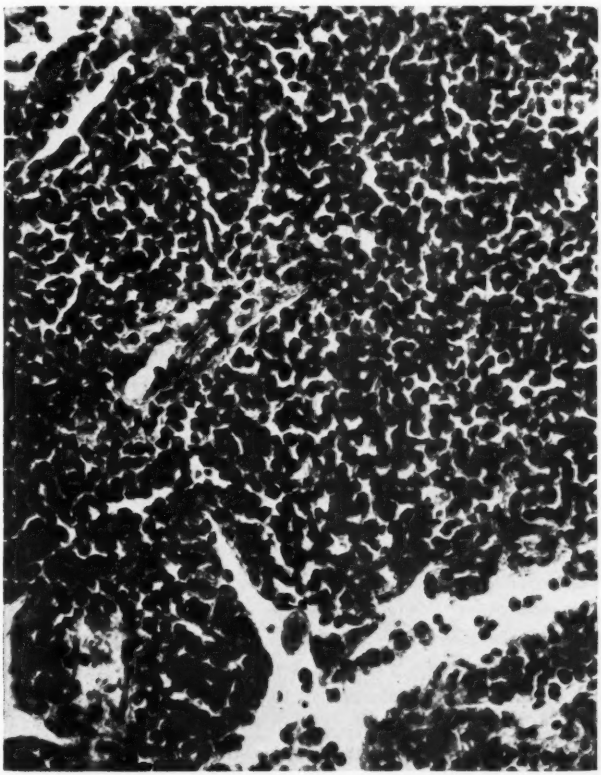

Fig. 3.—High magnification photomicrograph of lung tumor showing lymphomatous elements of fairly uniform size replacing the usual lung architecture.

The size of the tumors varied greatly. The smallest was reported as being 5 cm. in diameter. Several were massive, filling an entire lobe of the lung. Most of the tumors were discrete and, although they showed some local infiltration and were devoid of a capsule, they were definitely demarcated from the normal lung. Only four of the fifteen cases had metastases at the time of the operation. The mediastinum was involved in all of these; the liver, ribs, sternum, and brain being the sites of the more distant metastatic processes.

Of the fifteen patients in this group, thirteen were subjected to exploratory thoracotomy, and in eleven of these resective surgery was possible. Six were treated by lobectomy, while in five a pneumonectomy was performed. There was no surgical mortality in the group. We do not have late follow-up studies on any of the patients. The two patients who were explored but where the lesion was not resectable died at three and at nine months following the intervention. In both of these radiation therapy was used but appeared to be ineffectual. One patient died of a local recurrence and mediastinal extension four years after lobectomy. Of the ten remaining patients, we have some information in nine. All appeared to be in good health from six to thirty months following the operation. One patient (Ochsner and deCamp) was alive and well nine years following a pneumonectomy.

SUMMARY AND CONCLUSIONS

Primary lymphoma or lymphosarcoma of the lung is a rare disease, but should be found with increasing frequency with the more widespread use of mass radiography.

The six cases which have been individually reported in the literature have been analyzed. To this we have added one case of our own and eight others which were described personally to us by other surgeons. All of these have been reviewed from the standpoint of symptomatology, diagnosis, and therapy.

The diagnosis of pulmonary lymphoma can be made only after the tumor has been surgically explored.

The therapy appears to be resective surgery. It is impossible to state from this review whether there is any advantage in pneumonectomy over lobectomy. It appears, however, that lobectomy is probably adequate if the lesion is peripheral and small.

It is impossible to evaluate the results of radiation therapy in this disease. It would appear at least that its place is certainly secondary to resective surgery.

The importance of the surgical exploration of solitary lung tumors is stressed, even when it appears that these may be secondary to another focus.

We would like to express our appreciation to Drs. Moses Behrend, Arthur Touroff, Richard Overholt, Reeve Betts, Brian Blades, Alton Ochsner, and Paul T. deCamp for their kindness in furnishing information of their cases.

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